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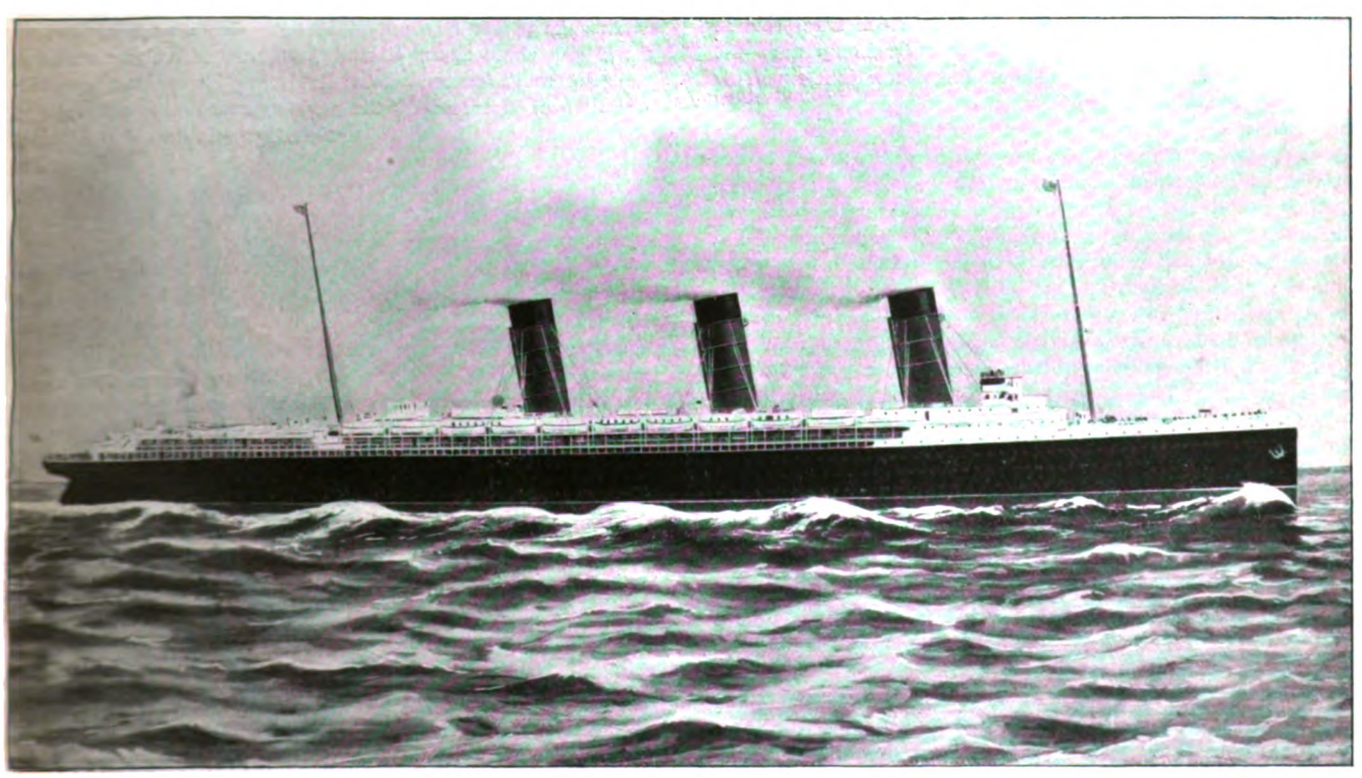
THE CUNARD LINE AND TURBINES.

Probably the most momentous step in the history of the Cunard Line since the sailing of the pioneer steamer Britannia in 1840 is the decision of the directors to adopt the steam turbine as the propulsive force for the two 25-knot steamers pointed last September to decide the knotty point of turbine or rotary versus reciprocating engines in connection with the forthcoming Cunarders had a difficult problem to solve. There was the experience of no ocean-going turbine liners to assist them; but after thorough and impartial research the



THE 25-KNOT TURBINE CUNARDERS BUILT UNDER SUBVENTION FROM THE BRITISH GOVERNMENT.

[*From a drawing supplied by the Cunard Steamship Co.*

which are to restore to the British flag the speed supremacy of the ocean. The marine steam turbine is quite a thing of today, for though it was in June, 1895, that the diminutive Turbinia startled the world by attaining a speed of 34½ knots, she was quite an experimental craft, built to demonstrate the applicability of the steam turbines to the propulsion of small vessels. She is 100 ft. long and 9 ft. beam with a displacement of 44½ tons, so that between her and the Cunarders with their 760 ft. of length there is a vast gulf, which even the subsequent cross channel turbine steamers have not abridged. The committee of experts therefore appointed committee, every member of which was an engineering expert of recognized ability and wide experience, decided to recommend that the new steamers should be propelled by turbine engines and the Cunard directorate with progressive enterprise and foresight have decided after anxious deliberation to adopt the recommendation.

Though it is only 9 years since the Turbinia demonstrated that a new era had dawned for marine engineering, scientists have been groping for ages to find a successful method of using steam directly, in the same manner as the water, falling upon the buckets of a water-wheel, rotates the shaft at

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its center. This water turbine has been in existence from time immemorial. The problem however to which countless generations of engineers have striven to find a solution is to use steam in the same economic manner to rotate a shaft. Hero of Alexandria who lived 120 B. C. had some glimmering of how this might be effected. He heated water in a hollow sphere, provided with escape nozzles set at different angles, and the rejected steam imparted a revolving motion to the sphere. Branca in 1629 advanced further, for he secured rotary motion by causing a jet of steam to impinge upon the vanes or blades of a wheel. These and other early steam turbines were more in the nature of toys than machines for doing work. The close of the eighteenth century however saw a great impetus given to the study of steam and its uses, and in 1784 we find the first recorded patent for a steam turbine, that of Kempelen. The better known James Watt who was an independent worker in the field, took out a patent in the same year. By 1850 over thirty patents for steam turbines had been registered while not a year has elapsed since, without inventors, in some cases to the number of scores, patenting their designs. Among these the name of the Hon. C. A. Parsons, son of Lord Rosse of telescope fame, appears in 1884, so that this mechanical genius has been working for over twenty years at the type of turbine with which he is now so illustriously indentified.

His turbine which will be adopted in the Cunarders is both simple and efficient. The steam raised in the boilers is conveyed to the cylinder inside which is a drum or hollow shaft studded with rows of blades which are set at an angle to the direction of the flow of steam, just as the sails of a windmill are trimmed to the wind. The first row of blades encountered by the rush of steam deflects it from its course so that it would not effectually operate on the next row were there not between each row of working blades a row of guide blades affixed to the inside of the cylinder casing and set at the reverse angle. These guide blades are stationary and their use is to again alter the direction of the flow of steam and bring it back to the straight course from one end of the cylinder to the other before it encounters the next succeeding row of working blades. The tips of the revolving blades almost scrape against the casing of the cylinder and the stationary blades almost touch the revolving shaft or drum. Thus there are practically a series of turbine wheels on one shaft and the steam after performing its work in one turbine, say the high-pressure, passes to the intermediate, thence to another or to the low-pressure turbine, all the while gradually diminishing in pressure and gradually expanding. It will be seen that there is no friction in the turbine and no wearing parts save the bearings on which the main shaft revolves. From the low-pressure turbine the steam passes to the condenser and thence back to the boiler where it re-enters as pure water inasmuch as no internal lubrication is required in the turbines.

The historic Britannia was justly considered the marvel of her age, but the new flyers will make the voyage between Liverpool and New York in a little more than one-third of the time, while along any one of their turbine driven shafts will be transmitted six times the total horse power developed by the engines of the pioneer Cunard fleet of four steamers which in the early forties carried the well known flag between the two continents. During the experimental stages of applying the steam turbine to ships considerable difficulty was experienced in the matter of maneuvering, reversing, going astern, etc. This obstacle to complete success has now been obviated and the new vessels will be able to come to a dead stop from full speed in a shorter time than if driven by reciprocating engines, while their maneuvering power will be unsurpassed by any steamers afloat. To the engineering profession the adoption of rotary engines means increased speed for the same boiler power, due to reduced weight of machinery and increased economy in steam; the cost of up keep is also less, while there will be a smaller engine room staff and a diminished bill for lubricants. The passenger however regards the matter from another standpoint. To him the adoption of turbines means an utter absence of all vibration and hence greater comfort, while the smaller engine room spaces and openings will ensure more commodious quarters and promenade space. To sum up; the mere fact that the Cunard directorate have adopted on the best expert advice, the steam turbine, is proof positive that the rotary engine is the marine engine of the future and it is quite in keeping with Cunard traditions that they should have decided upon the system only after thoroughly convincing themselves that the steam turbine possesses economical advantages over the reciprocating engine and that it is an efficient, reliable and safe system of propulsion.

Engineering details are not yet obtainable but the commission recommend four shafts, not only because the four screws will give a higher efficiency, but because it is imprudent to divide the power through a smaller number of shafts. The commission considered the power necessary to give the sea speed of 24½ knots with various forms of hull, and although 24½ knots can be realized at sea under normal weather conditions it is necessary to have a considerable margin of power to insure that this rate will be maintained under adverse conditions; and for this reason 25 knots will be attained on an extended trial trip. Consequently, with three shafts, the power transmitted through each would require to have been about 25,000 I. H. P., whereas, with four shafts it will not much exceed 18,000 I. H. P. There was also the question of the size of the turbine and the advantage of limiting the number of revolutions per minute of the screw propellers. Large diameter improves the sea maneuvering quality, and the committee started with the proposition that the revolutions should be limited to 140 per minute. This is considerably more than with reciprocating engines, but it compares with 300 to 500 revolutions at which smaller turbine-driven vessels are now run. The design of turbine will differ slightly from that in other ships, but the commission did not consider other systems than the Parsons, since there has been no sea experience with others. Although the rate of revolution is low, the turbines will require to be of great diameter to give the power, and the peripheral speed will consequently be very high, but no greater than with existing turbines. The greater diameter of the turbines affects their arrangement in the machinery room of the ship. As recommended, there will be one go-ahead turbine on each of the four shafts, which will be equidistant from each other. The high-pressure turbines will be mounted on two outside shafts, which will enable the shafts to be far from the center of the ship without interfering with the lines of the hull. These shafts will have the propellers at a considerable distance from the stern of the ship, and thus there will be the minimum of disturbance to the flow of water to the two inside propellers, which will be placed right aft in the usual way. On each of the two inside shafts there will be two turbines. On each there will be two low-pressure turbines for driving the ship ahead. The other two are for driving astern. The power for ahead motion is in two steam units, each with one high and one low-pressure turbine, giving the best expansion of steam; but should there be any breakdown of one shaft, turbine or propeller, the three remaining shafts may be run, and thus only one-fourth of the power will be unavailable. Since the turbine can be overloaded to a greater extent than the reciprocating engines, it will be possible to reduce this proportion of lost power considerably, and with a fractured shaft the sea speed may not fall short of the normal rate by more than a mile or a mile and a half per hour.

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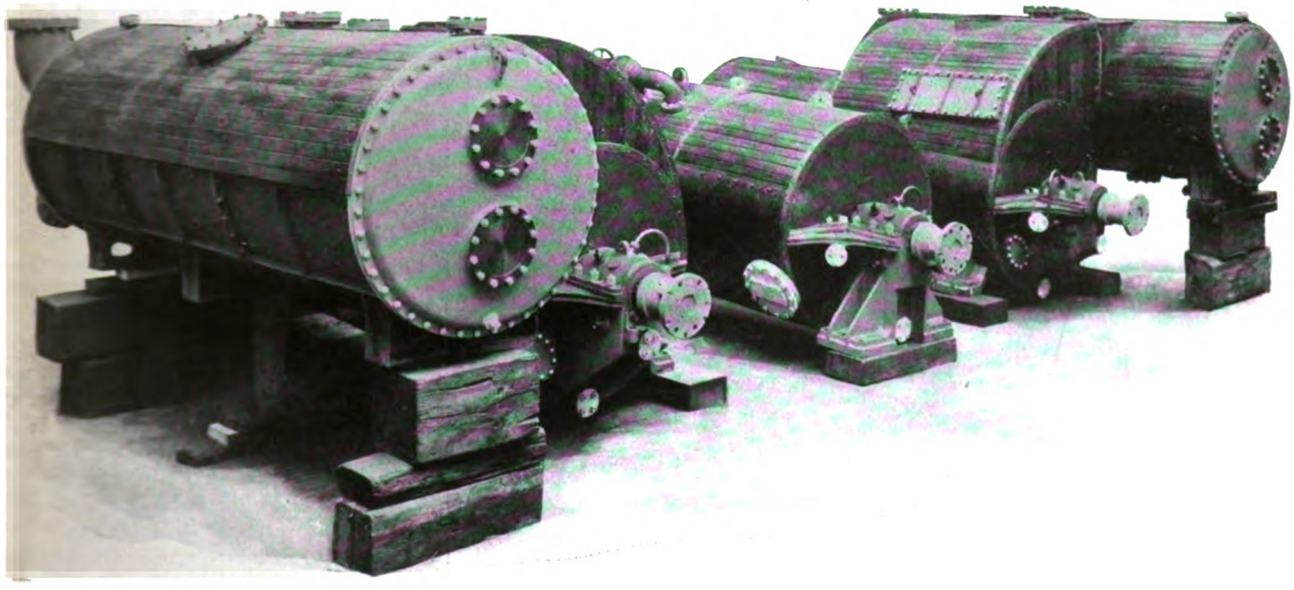
TURBINE ENGINES OF THE NEW ALLAN LINERS.

Glasgow, June 30.—For the benefit of the Marine Review I am enabled, by the courtesy of the owners and of the Parsons Co., to submit the following information bearing on the machinery of the two turbine steamers now being built for the Allan Line—one by Workman, Clark & Co., Belfast, the other by Alexander Stephen & Sons, Glasgow. In a former article the general plan and character of these steamers were described, and the reasons were assigned which induced the Allan company to make the large venture of being the first to adopt turbine machinery for transatlantic navigation. The vessels are now in course of construction, but are not at a stage at which counterfeit presentments of the engines can be shown in print. I must, therefore, deal with general description, illustrated with a photograph of a complete set of marine turbine engines similar to those which are now being constructed for the Allan liners. The turbine is, of course, like an inverted water-mill, and the principle on which it produces rotary motion is just that of the time-honored wind-mill—with this difference, that steam instead of wind supplies the force. The arms and sails of the windmill are represented in the turbine by metallic vanes set on a conical casting forming the forward end of the propeller shafting. These vanes work into flutings on a fixed hollow casting which surrounds them. When the steam is projected into this arrangement of blades it can only find passage by forcing the parts attached to the shafting into rapid revolution. Aided by the withdrawal of atmospheric pressure at the other end by means of powerful air pumps, the steam entering at very high pressure as it expands gives a ceaseless steady rotary movement to the shafting.



SHOWING WHAT THE PARSONS TURBINE ENGINES FOR THE ALLAN LINERS WILL LOOK LIKE.

The Parsons' turbine, then, consists of a cylindrical case with numerous rings of inwardly projecting blades. Within this cylinder, which is of variable internal diameter, is a shaft or spindle, and on this spindle are mounted other blades, projecting outwardly, by means of which the shaft is rotated. The former are called fixed or guide blades, and the latter revolving or moving blades. The diameter of the spindle is less than the internal diameter of the cylinder, and thus an annular space is left between the two. This space is occupied by the blades, and it is through these the steam flows. The steam enters the cylinder by means of an annular port at the forward end; it meets a ring of fixed guide blades which deflects it so that it strikes the adjoining ring of moving blades at such an angle as to exert on them a rotary impulse. When the steam leaves these blades it has naturally been deflected. A second ring of fixed blades is therefore, interposed, and these direct the steam on to the second ring of rotating blades. The same thing occurs with succeeding rings of guide and moving blades until the steam escapes at the exhaust passage.

The general principles and leading details of the Allan steamer's engines and arrangements are those of the first turbine steamer constructed by the Parsons company. The turbine has three screw shafts, each of which is driven by a Parsons' steam turbine of the parallel flow type, the general course of the steam through them being parallel to the axis. Each turbine consists (as above) of a truly bored cylindrical case, with numerous rows of inwardly projecting guide blades attached to its inner surface, which almost touch a light steel drum mounted on the shaft, and running in bearings at each end of the case. On this drum are attached rows of moving blades complementary to those on the case, and projecting outwardly, and nearly touching the case. The steam enters at the forward end, and, passing from ring to ring of blades, is first projected by the guide ring blades on to the moving blades, then it reacts back on to the succeeding row of guide blades, and is then thrown forward again on to the second row of guide blades, and so on throughout the series. As it passes from ring to ring it falls in pressure and expands, and to meet this expansion the blades are increased in height in steps at succeeding rings, the blades at the exhaust end being much taller than those in the initial rows. The turbine shaft is rigidly coupled to the screw shaft, and the thrust of the propeller is steam-borne. The steam entering an annular space at the forward end of the drum presses aft on the blades; forward of the entry the drum is suitably reduced in size, and is ground so as to form, with the solid brass rings attached to the case, a steam-tight rotating piston. The steam presses aft on an annular part of the drum at the same time as it presses on the blades, and the sum of these pressures equals the thrust of the propeller. To meet any unbalanced thrust, such as is set up when steam is turned on or off suddenly, and to maintain the true longitudinal alignment of the motors, a thrust block is provided at the forward end of the casing.

The three turbines are similar in general design and form a compound series, consisting of the high-pressure, the intermediate, and the low-pressure turbine, through which the steam flows and exhausts directly into the condenser. Forward of the low-pressure turbine, and coupled in line with it is the reversing turbine which exhausts directly to

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the condenser. To prevent ingress of air where the shafts enter the castings the metallic packings are made in lantern form in which a steam pressure is maintained at about atmospheric pressure by small regulating and reducing valves.

The machinery of the two Allan liners will be arranged like that of the turbine channel steamer the Queen, which is applicable to most vessels fitted with the turbine system of propulsion. There are three turbines, viz:—one high-pressure in the center of the ship and two low-pressure, one on each side of ship. Each turbine drives a separate shaft, with one propeller on each shaft, three in all. Inside the exhaust casing of each of the low-pressure cylinders a reversing turbine is fitted. In ordinary going ahead, the steam from the boilers is admitted through a suitable regulating valve to the high-pressure turbine, and after expanding about 5 fold, it then passes to each of the low-pressure turbines in parallel, and is again expanded in them about 25 fold, and then passes to the condensers, the total expansion ratio being 125 fold. When coming alongside a jetty or maneuvering in or out of harbor, the outer shafts of the Queen only are used, and the steam is admitted by suitable valves directly into the low-pressure turbines, or alternately in the reversing turbines as may be desired. With this arrangement the port or starboard engines are capable of being worked ahead or astern independently of each other and of the high-pressure turbine, the high-pressure turbine rotating idly in a vacuum whilst the vessel is maneuvering.

Mr. Parsons has devised a modification of his earlier designs to suit Atlantic requirements. Great power will be attained both for forward and backward movement. It will be transmitted through shafting, and by means of propellers of special strength and design, run at a speed moderated to the conditions of Atlantic work, and contrived to give steady efficiency without undue strain, and free from all vibratory disturbances. Special care is being taken to have workmanship of the very highest class, and boiler power and specially adapted pumps, valves, condensers, and other allied parts.

There is a special arrangement devised by Mr. Parsons for the Allan liners, whereby a reversing power equal to that of the forward propelling power can be imparted to the machinery securing almost instant arrestment of the ship's forward motion, and speedy backing in case of need. In this matter they will surpass the ordinary engine-propelled steamer. The widespread arrangement of propellers, of which there are three in number, each on a separate length of shafting, and the rapidity with which power can be directed upon each of the outer shafts separately, in any direction, will greatly assist the ship's maneuvering power.

The engines for the Victorian are being constructed under license by Workman, Clark & Co., in their own engine shops. Those for the Virginian, which is being built by Alexander Stephen & Sons at Glasgow, are being constructed by the Parsons Marine Turbine Co. at their works at Wallsend. The photograph gives a good general idea of both sets.

TURBINE STEAMER FOR MIDLAND RAILWAY

There was launched from Messrs. Vickers Sons & Maxim, Ltd., of Barrow last month, the turbine-driven steamer, the Manxman, which has been specially designed and constructed for the Midland railway service between Hezsham and the Isle of Man. The Manxman has four decks instead of three. Her length of waterline is 330 ft., her breadth 43 ft., and her depth 25 ft. 6 in. The vessel which has been designed by Messrs. Biles, Graz & Co., the consulting architects for the Midland railway company, is to attain a speed of 20 knots. There is every prospect, however, that she will easily attain a speed of something like 22 knots, because there has been in her case a material development of the turbine principle. Hitherto the Parsons' turbine has taken steam from the boilers working at 150 lbs. pressure, but in the turbines which Messrs. Parsons are making for this ship, steam will be used at 200 lbs. pressure, and it is anticipated that as a consequence, the speed will be materially increased and the economy improved. There are three shafts, each with a separate turbine, the high-pressure turbine being on the center shaft, while the two low-pressure turbines are mounted on the side shafts. The turbines for going astern are also mounted on the side shafts. The Manxman is one of four vessels ordered by the Midland railway company, two of which are to be fitted with turbine engines.

The two turbine steamers will be pitted in service against the two reciprocating engine steamers, one of which, the Clydebank boat Antrim, has given exceptionally good results by making 21.9 knots as a mean speed for six runs over the measured mile at Skelmorlie—a performance to equal which will severely test the turbine machinery. The vessel with the latter plant will have the advantage of the economy of 200 tons in weight saved upon the engines in the case of the Londonderry. The higher pressure in the Manxman has necessitated more weight; but this, it is expected, will be more than compensated for by increased speed and economy. As some indication of how this saving is effected, it may be noted that the diameter of the propeller shaft for the reciprocating engine is 12 in. as against 8 in. for the turbines, the weight of the shaft for the latter being only 45 per cent of that of the former. The propellers, of course, differ in diameter very materially, as it is anticipated that the reciprocating engines will run at 180 revolutions, whereas the turbine propellers will make 500 revolutions in the case of the side screws and 600 for the two center propellers. The three-bladed propellers in the case of the reciprocating engine ships have a diameter of 11 ft., while the screws of the turbine-driven vessel are four-bladed, and have a diameter of 5 ft. 6 in. As to the cost of manufacture of the two types, it may be said that at present it is about the same—the turbines are perhaps more costly—but it should be noted that while in the case of the ordinary reciprocating engine manufacturing methods have been perfected as the results of the accumulated experience of two or three generations, the turbine machinery is still in its infancy, especially in respect of manufacture. The probabilities are that improvements in constructive methods will bring about a material advantage for the new type of prime mover. The cost of running is undoubtedly lower, there being in the turbine ships at least two men less in the engine-room than in the case of ships with ordinary machinery.

TURBINES FOR GERMAN NAVY.

The German navy has ordered twenty-two Parsons turbines as motive power for the dynamos of a number of new ships. The battleships Ersatz, Deutschland, Roon, Hessen, and N will each receive four of these sets of 65 kw. They will be used for lighting purposes, for training the heavy guns, for ammunition hoists, and for operating the gun turrets. The small cruisers Berlin, Lubeck, and M will each receive two sets of 45 kw. each. The French torpedo-boat No. 293, built at Normands, and fitted with Parsons turbines, has gone through her speed trials and obtained a speed of 25¼ knots under most unfavorable conditions. The torpedo-boat No. 243, which two years ago left the slip of the Chantiers de la Mediterranée, and is also fitted with turbines, will receive new propellors. Up to now she had three 3-blade propellors, while now five 3-blade propellors will be mounted.

The steel tug Columbia, being built for the Baker-Whitely Coal Co., was launched from the shipyard of the John Dialogue Co., Camden, N. J., last week. The Columbia is 110 ft. long, 23 ft. beam and 11 ft. 6 in. depth of hold. She will be fitted with fore and aft compound engines, with cylinders 16 in. in diameter and 24 in. stroke of piston.

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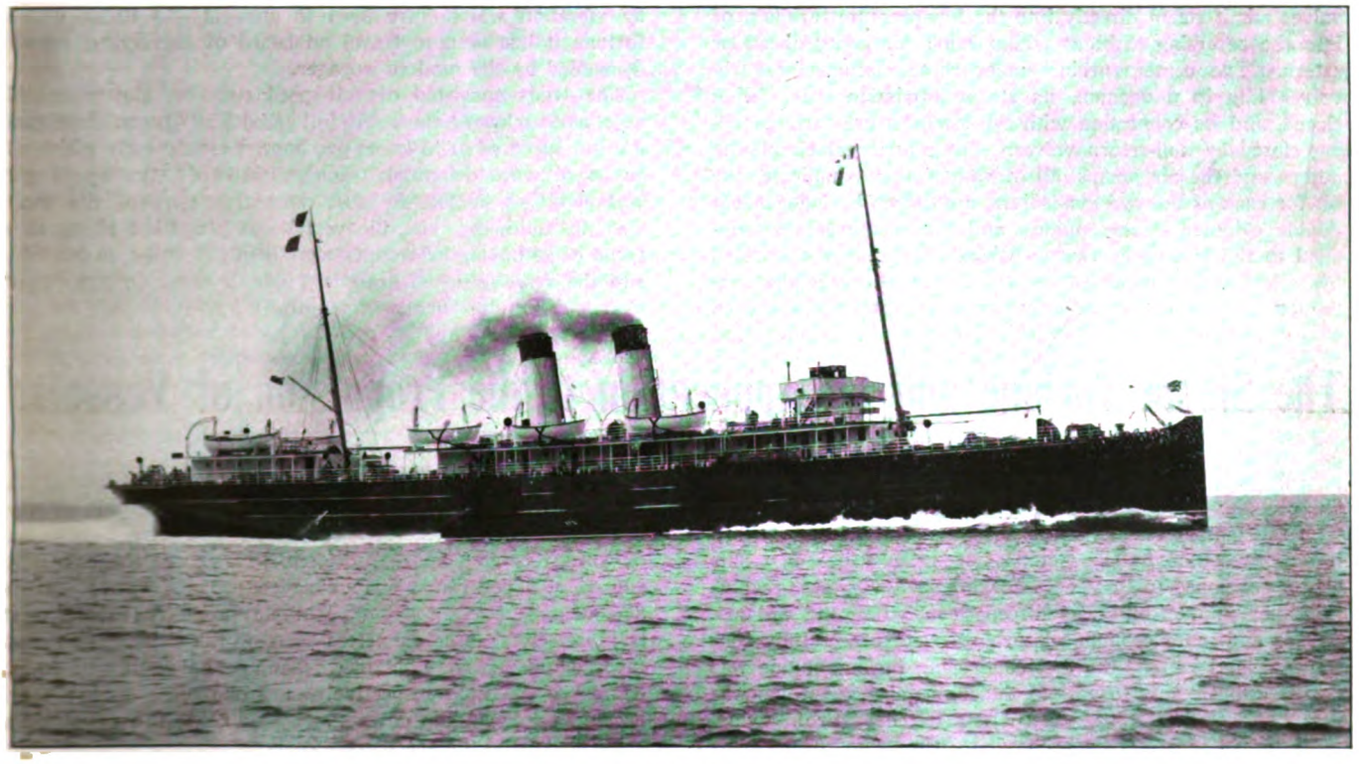
TURBINE STEAMER QUEEN.

The Queen marked the first departure from the accepted method of propelling steamers across the English channel. Hitherto they were all either paddle-wheel or twin-screw but the Queen was equipped with turbines and is an enlarged example of the turbine steamers used on the Clyde. The new vessel is 310 ft. long, with a molded breadth of 40 ft., and a depth of 25 ft., and has a complete awning deck. In large deckhouses on this deck there are a number of special cabins provided for the convenience of passengers. Amidships is the smoking-room, framed in waxed oak in a free classical design, and upholstered in leather. The seats are arranged in bays with small tables, and the floor is laid with ornamental tiles. Above this first-class accommodation there is a promenade deck extending out to the ship's side, which shelters the awning deck in wet or rough weather, and provides a large promenade for passengers in fine weather. The ladies' accommodation is in a large apartment on the main deck, framed in oak and enamelled pine, with broad frieze of anaglypta. The doors are in leaded glass richly colored. A feature of this apartment is the fireplace, with brass interior and tiled panels of special design, the overmantel having a beautiful dolphin clock. The settees of the apartment are upholstered in cretonne and arranged with spring seats to form berths for use on the night passage. Immediately below this is a gentlemen's sleeping saloon, framed in panelled oak, with shell pattern frieze and upholstered in rich leather. Abaft this is the restaurant, also panelled in oak, with anaglypta frieze representing ancient war galleys. Large dining tables are provided with revolving chairs, capable of accommodating about 50 passengers. The galley, which is in connection with a pantry above by means of a hoist, is fitted with a very complete appointment of steam cooking appliances. All the first-class vestibules are framed in light oak waxed, and the interior doorways have leaded glass panels. Twelve staterooms and two special royal staterooms are provided on the upper deck. The ordinary staterooms are finished in white enamel, with red figured cretonne. The special royal staterooms are in white, richly ornamented, with upholstery in cretonne to match. The second-class accommodation is situated aft, the ladies' cabin being in large deckhouse on awning deck, the roof of which extends out to ship's side, forming a sheltered promenade in wet weather. The gentlemen's accommodation is on the lower deck, and consists of comfortably upholstered sofa beds for the night service. A large open space is also provided on the main deck as a shelter during the day service. The crew are accommodated on the lower deck right aft, and the officers and engineers on the main deck amidships. The appliances for working the vessel are exceptionally powerful. As very heavy mails have to be frequently handled on this service, the vessel is provided with derricks and two large winches for dealing promptly with this matter. The vessel is heated throughout the passenger accommodation by means of a system of steam piping, and is fitted throughout with electric light and electric bell installation, the work being done by the builders.



TURBINE STEAMER QUEEN.

[*Built by William Denny & Bros., Dumbarton, Scotland.*

The machinery consists of Parsons' turbines, three being fitted, having three lines of shafting. In maneuvering the center shaft runs free, the two side shafts then take the place of ordinary twin-screws, and, as has been demonstrated in the Queen Alexandra, the maneuvering power is in every respect as good as in ordinary twin-screws, while in the going astern there is none of that objectionable vibration which is to be felt in the most modern twin-screw, balanced arrangement. The usual triple-expansion engines are in the case of the Queen replaced by turbine machinery on the latest improved plan, as designed by Mr. Parsons. The main engines in the Queen consist of three separate turbines, each driving its own line of shafting, the center turbine being high pressure and the two side ones being low pressure. When going ahead in ordinary work the steam is admitted to the high-pressure turbine and after expansion there, passes to the low-pressure turbines and then to the condensers, the total ratio of expansion being about 125-fold, as compared with eight to sixteen-fold in triple-expansion reciprocating engines. At the ordinary steaming speed of the Queen, the revolu-

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tions of the center shaft are about 700, and of the two side shafts about 500 per minute. This high rotative velocity implies the adoption of propellers of small diameter, and the utmost care is exercised in balancing them so as to obtain the full advantage of the absence of vibration obtained by the adoption of the turbine principle. When going full-speed ahead all the lines of shafting—central as well as side—are in full action; but when coming alongside a quay, or maneuvering in or out of harbor, the outer shafts only are used, thus giving the vessel all the turning and maneuvering efficiency of a twin-screw. The means for obtaining this maneuvering power demand a word or two of explanation. Inside the exhaust end of each low-pressure turbine cylinder is placed an astern turbine, controlled by slide valves operated by combined steam and hydraulic reversing engines. These valves admit steam directly into the low-pressure turbines, or into the reversing turbines within same for going ahead or astern. The center turbine under these circumstances revolves idly in a vacuum, its steam admission valve being closed, and its connection with the low-pressure turbines being closed by non-return valves. The centrifugal circulating pumps and the air pumps, all of which are in duplicate, one set for each of the two condensers, are driven by independent double cylinder steam engines, and the feed water is supplied to the boilers by two of Weirs' feed pumps controlled by a float tank into which the air pumps discharge the condensed water. There are also special pumps for wash deck and fire service, as also the various pumps for oil and water circulation as required by Parsons' system. Steam is supplied to the turbines by two double and two single-ended boilers, Scotch cylindrical type, constructed by Messrs Denny & Co., the working pressure being 150 lbs. One noteworthy feature on board The Queen will be the absence of the hot cinders and dust, which are, and more especially to ladies, such a nuisance on board most steamers fitted with forced draft. The funnels of the latest Dover and Calais steamers are fitted with the Denny and Brace spark arrester, by the use of which the decks can be kept as clean as those of a yacht. To conclude, the adoption of the Parsons' turbine principle of propulsion for high-speed vessels not only gives a substantial increase of speed, but also by its freedom from reciprocating parts completely obviates those troubles caused by vibration which have been so annoying to those whose fortune it has been to travel on board of the flying vessels demanded by the modern voyager.

The trials consisted of full-speed runs on the measured mile, and backward runs. At full speed The Queen developed a mean speed of 21.76 knots per hour, a result with which all on board were delighted. Going backwards, the speed got was about 13 knots. A most interesting part of the trials was the following, viz., the vessel was propelled along at a speed of 20 knots, the engines were then put full-speed astern, and the vessel stopped dead in 1 min. 7 secs., in 775 ft., or exactly 2½ times her own length.

The Steam Turbine and Its Application to the Propulsion of Vessels.*

By the HON. C. A. PARSONS.

In the year 1884 the first compound steam turbine engine was built by the writer, and applied to the driving of a dynamo with satisfactory results, and after some years of useful work it was presented to the South Kensington Museum. This engine developed 10 H. P. at a working speed of 18,000 revolutions per minute, and was directly coupled to the dynamo. Larger and more economical turbines were successfully constructed, and in 1888 the first condensing turbine engine was designed, but owing to various difficulties such a turbine was not constructed till 1892, when it was tested by Prof. Ewing, F. R. S., in view of the proposal to use steam turbines for the lighting of Cambridge. This engine was of 200 H. P. at a working speed of 4,800 revolutions per minute, and consumed 27 lbs. of steam per Kilowatt hour, which is equivalent to about 16 lbs. of steam per indicated horse power per hour. In recent years turbines for driving alternators and dynamos have been built in England and on the continent under our patents, aggregating upwards of 250,000 H. P., and in size up to 5,000 H. P. and the results have been most gratifying.

Consumptions of steam as low as 15.8 lbs. per Kilowatt, or about 9.8 lbs. per I. H. P. per hour, have been recorded when using steam at 142 lbs. pressure delivered to the engine at 250° C. Further, the plants now on order in England and on the continent comprise many units of upwards of 9,000 H. P. The result of Prof. Ewing's test in 1892 impressed the minds of those interested with the conviction that the steam turbine would probably, in the near future, supersede the reciprocating engine for certain fields of work, and, among them, for the propulsion of ships. Two years later, January, 1894, a pioneer syndicate, The Marine Steam Turbine Co., was formed, the chief members being the Earl of Rosse, C. J. Leyland, George Clayton, Norman C. Cookson, H. C. Harvey, John B. Simpson, A. A. C. Swinton, G. G. Stoney, and the writer. The Turbinia, the first vessel fitted with the steam turbine, was constructed at Wallsend-on-Tyne. The first preliminary trial was on Nov. 14, 1894, and during the two succeeding years many alterations and thirty-one trials were made. A single compound turbine engine of the radial type was first fitted, which drove one shaft. Seven different arrangements of propellers were tested, commencing with a two-bladed propeller of 30 in. diameter, and 27 in. pitch, which gave the excessive slip of 48.8 per cent.; a four-bladed propeller gave similar and unsatisfactory results. Multiple propellers were next tried, set about three diameters apart on the shaft. The most favorable results were obtained from a set consisting of 20 in., 22 in., 22 in. pitch respectively, and one pitch ratio; these brought the mean slip down to 37.5 per cent., the revolutions being 1,780, and the speed 19¾ knots.

Nine different sets of propellers in all were tested, and the results compared with the power registered by a transmission dynamometer showed in every case a very low propeller efficiency. The original turbine engine was removed and replaced by three separate turbines—high, intermediate, and low-pressure, each driving a shaft. The trials commenced again in February, 1896, with three propellers of 18 in. diameter and one pitch ratio on each shaft, making nine in all, which gave favorable results. Several sets were then tried; nine propellers of 24 in. pitch and 18 in. diameter were eventually adopted as apparently giving the best results, though some recent experiments have shown single propellers on each shaft to be preferable. The division of the turbine, thereby applying one-third of the total power on to each of the three shafts at once, gave a great increase of propeller efficiency and speed, an approximate estimate being that the propulsive horse power was about doubled by the change, so that speeds up to 32 knots were obtained. The vessel was, in April, 1897, placed in the hands of Prof. Ewing, F. R. S., and from his report the following condensed description has been taken, viz.:—

The Turbinia is 100 ft. in length, 9 ft. beam, and has a displacement under trial conditions of 44½ tons. She has three screw shafts, each of which is driven by a Parsons steam turbine of the parallel flow type, the general course of the steam through them being parallel to the axis; each turbine consists of a truly bored cylindrical case, with numerous rows of inwardly projecting guide blades attached to its inner

*Paper prepared for Institution of Naval Architects

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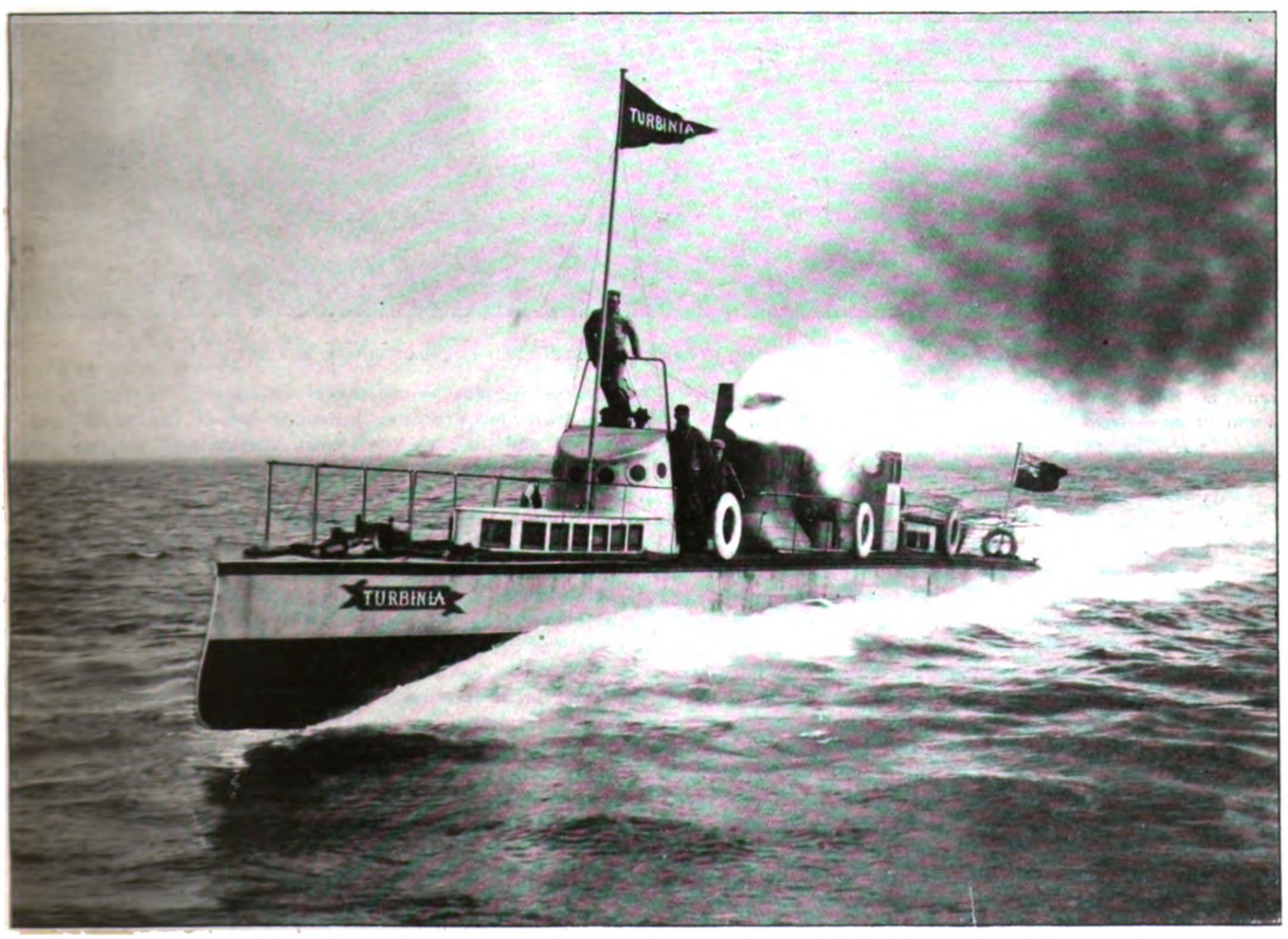
surface, which almost touch a light steel drum mounted on the shaft, and running in bearings at each end of the case; on this drum are attached rows of moving blades complimentary to those on the case, and projecting outwardly, and nearly touching the case. The steam enters at the forward end, and, passing from ring to ring of blades, is first projected by the guide ring blades on to the moving blades, then it reacts back on to the succeeding row of guide blades, and is then thrown forward again on to the second row of guide blades, and so on throughout the series. As it passes from ring to ring it falls in pressure and expands, and to meet this expansion the blades are increased in height in steps at succeeding rings, the blades at the exhaust end being much taller than those in the initial rows.

The turbine shaft is rigidly coupled to the screw shaft, and the thrust of the propeller is steam-borne by the following arrangement: The steam entering an annular space at the forward end of the drum presses aft on the blades. Forward of the entry the drum is suitably reduced in size, and is ground so as to form, with the solid brass rings attached to the case, a steam-tight rotating piston. The steam presses aft on an annular part of the drum at the same time as it presses on the blades, and the sum of these pressures equals the thrust of the propeller.

To meet any unbalanced thrust, such as is set up when steam is turned on or off suddenly, and to maintain the true longitudinal alignment of the motors, a thrust block is provided at the forward end of the casing. The three turbines are similar in general design and form a compound series, consisting of the high-pressure, the intermediate, and the low-pressure turbine, through which the steam flows and exhausts directly into the condenser. Forward of the low-pressure turbine, and coupled in line with it is the reversing turbine which exhausts directly to the condenser. To prevent ingress of air where the shafts enter the casings the metallic packings are made in lantern form in which a steam pressure is maintained at about atmospheric pressure by small regulating and reducing valves.

The bearings of the turbines are formed of gun-metal bushes surrounded by three eccentric loosely fitting tubes; in the interstices between the tubes the oil film forms a cushion and damps vibration. All the main bearings are under oil pressure, and sufficient open spaces are provided to ensure that no oil can enter through the shaft bearings into the turbines. The fan for forcing the boiler is mounted on a prolongation of the reversing turbine shaft. The exhaust pipe is of unusual sectional area, and is calculated for a ratio of expansion of about two hundredfold in the turbines. The condenser has a cooling surface of 4,200 sq. ft., and the circulation of water is maintained by hinged scoops, by which the direction of flow can be reversed to clean out any obstruction of the tubes, which are 5-16 in. internal diameter, and an auxiliary circulating arrangement is provided to maintain the circulation when the vessel is at rest.

The boiler is a double-ended one, and has a heating surface of 1,100 sq. ft., and 42 sq. ft. of grate surface; is of the straight tube type, the tubes being ½ in. internal diameter, and 1-16 in. thickness; two return water tubes of 7 in. diameter at each end connect the top drum with the water pockets. The diameter of the top drum is 34 in., and sufficient to enable a



THE TURBINIA, FIRST VESSEL TO BE EQUIPPED WITH TURBINE. TAKEN WHILE STEAMING 35 KNOTS.

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tube to be drawn and replaced by a workman in the top drum. The weight of the turbine engines is 3 tons 13 cwts.

The total weight of machinery, boiler, screws, shafting, tanks, &c.	22	tons
Weight of hull complete	15	"
Coal and water	7½	"
Total displacement	44½	tons

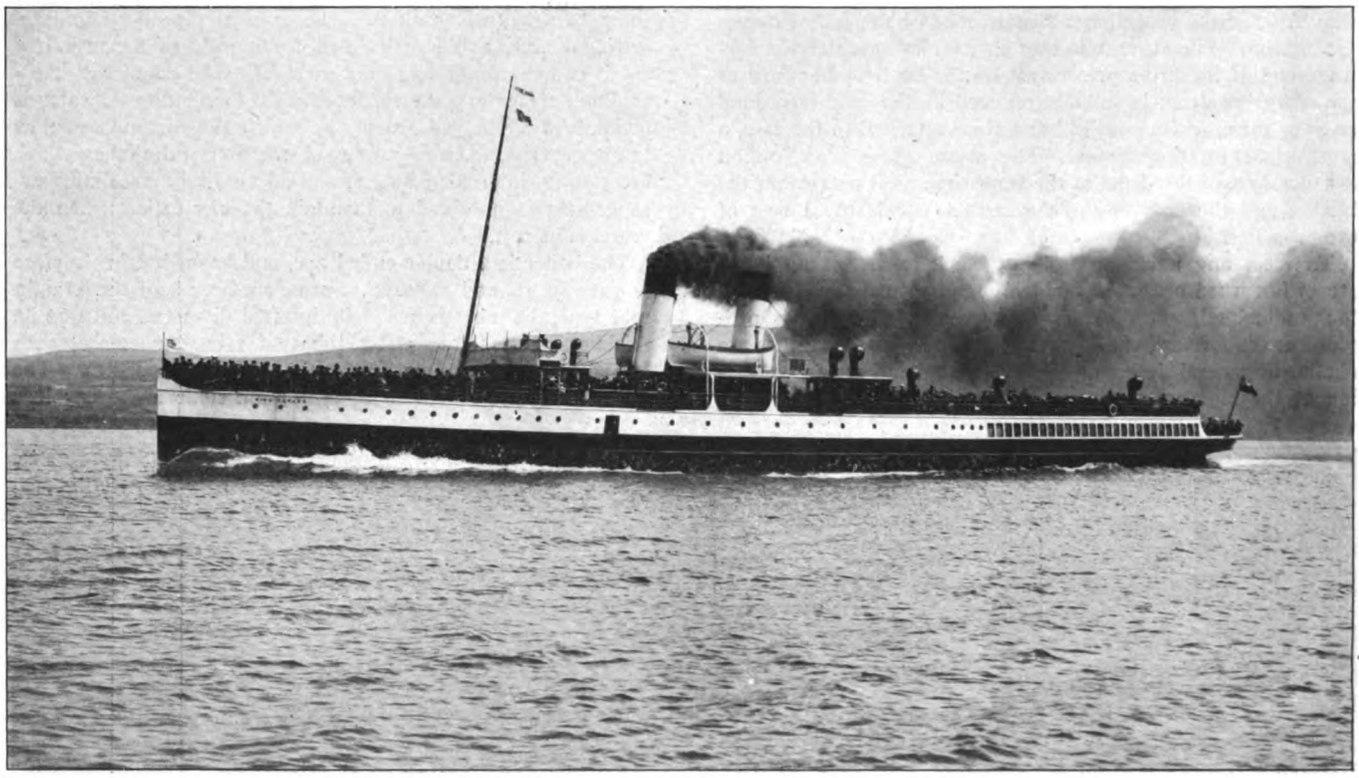
Numerous feed-water measurements were made at speeds ranging from 8 to 31 knots, that the total feed-water for all purposes at 31 knots was 30.0 lbs. per propulsive horse power, and that the horse power was derived from model experiments carried out on the lines of the late Mr. W. Froude with extreme accuracy. Also that the mean of two runs on the measured mile showed a speed of 32.76 knots, which was exceeded a few months later, when a speed of about 34 knots was maintained from Spithead to Southampton water.

In May last year trials were made with one propeller on each shaft instead of three on each shaft. A series of runs was first made with her original nine propellers, when it was found that the speed and steam pressure followed exactly the same curve as that obtained by Prof. Ewing six years previously, proving that no deterioration had taken place in the turbines, the vessel having undergone many trials, and having been to the Solent and back, and to Paris and back in the interval. She was next run with three propellers of 28 in. diameter and 28 in. pitch.

The single propellers show the greatest advantage at about 21 knots, where the gain amounts to 2 knots. The loss of efficiency which has been observed at certain speeds in some vessels fitted with tandem propellers on each shaft seems to be due to interference and cavitation.

The tendency was next to apply the turbine to vessels in which the conditions were most suitable to an essentially high-speed engine, and from the Turbinia the step to torpedo-boat destroyers was a short one; the matter was placed before the admiralty in July, 1897, and the order for the Viper was placed with the Parsons Marine Steam Turbine Co., at Wallsend-on-Tyne, in January, 1898, for a 31-knot torpedo-boat destroyer, of the same dimensions as the usual 30-knot vessels of this class, viz., 210 ft. in length, 21 ft. beam, and about 370 tons displacement, but with machinery of much greater power than was usual in vessels of this size. Sir W. G. Armstrong, Whitworth & Co. also contracted with the company for machinery for one of their torpedo-boat destroyers, afterwards called the Cobra.

The turbine engines of these vessels were similar to those of the Turbinia, but they consisted of two distinct sets of engines on each side of the vessel. There were four screw shafts in all, entirely independent of each other, the two on each side being driven by one high and one low-



KING EDWARD, THE FIRST TURBINE STEAMER CONSTRUCTED FOR PASSENGER SERVICE

pressure turbine respectively of about equal power. The two low-pressure turbines drove the two inner shafts, and to each a small reversing turbine was also permanently coupled and revolved idly with them when going ahead. The screw shafts were carried by brackets as usual, and two propellers were placed on each shaft, the foremost in each case having a slightly lesser pitch than the after one. In the Cobra, three propellers on each shaft were subsequently adopted. The thrust from the screw shafts was entirely balanced by the steam acting on the turbines, so that there was extremely little friction.

The boilers, auxiliary machinery and condensers were of the usual type in such vessels, but their size was somewhat increased to meet the much larger horse-power developed, and to compensate for the lesser weight of the main engines shafting, propellers, as well as the lighter structure of the engine beds. The boilers were of the Yarrow type, with a total heating surface of 15,000 sq. ft., and grate surface of 272 sq. ft. The condensers had a total cooling surface of 8,000 sq. ft. The hull and all fittings were of the usual design, except that the rudder and steering gear were considerably increased in strength to meet the greater power and speed contemplated in the contract.

Let us consider the machinery on one side of the vessel only.

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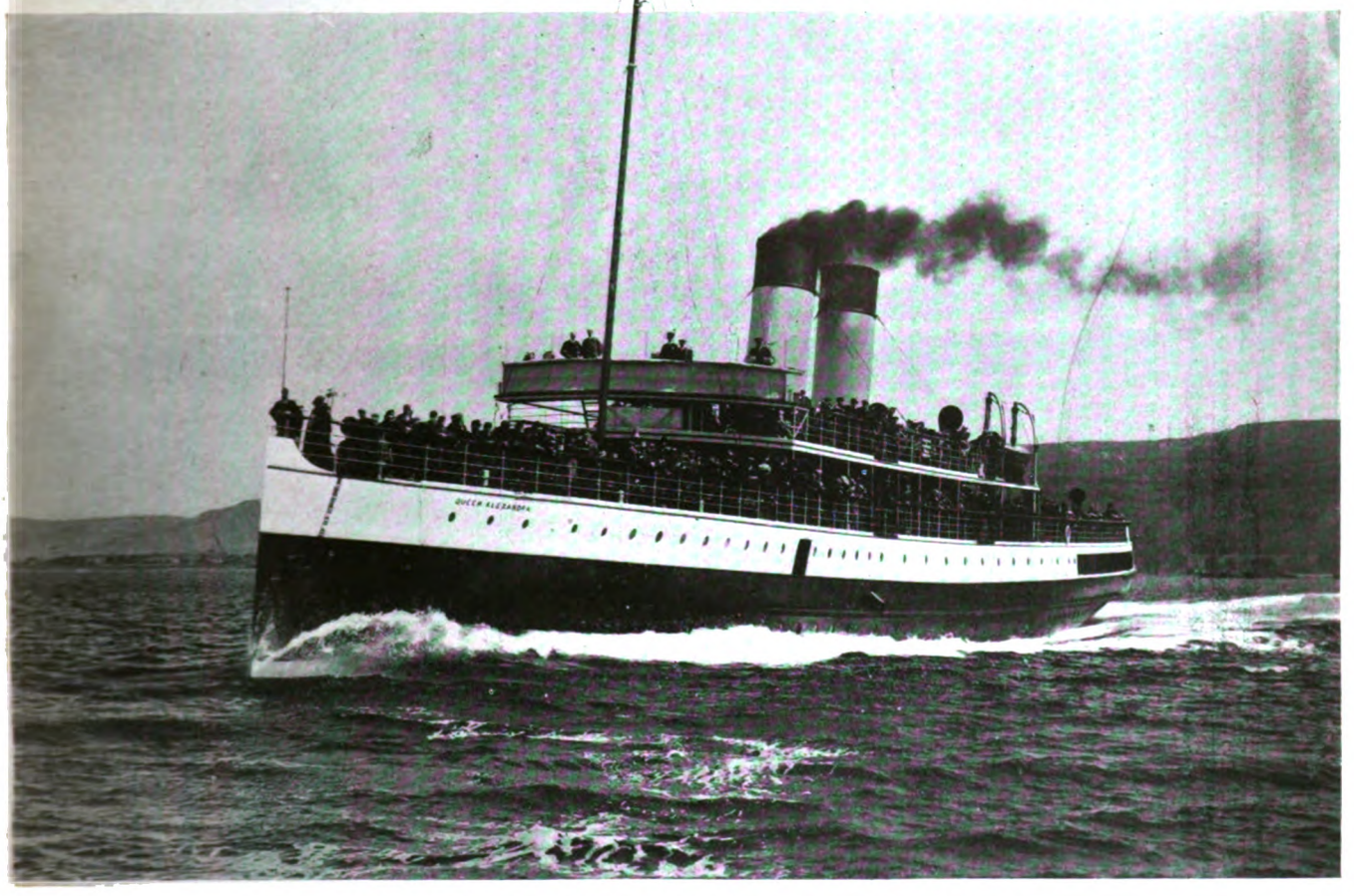
The steam from the boilers is admitted directly through a regulating valve to the high-pressure turbine driving the outer shaft. It then passes to the adjacent low-pressure turbine, driving the inner shaft. Thence it flows to the condenser, and both the shafts then drive the vessel ahead. The reversing



QUEEN ALEXANDRA, TURBINE PASSENGER STEAMER ON THE CLYDE.

turbine revolves with the low-pressure shaft, and, being permanently connected with the vacuum of the condenser, no appreciable resistance is offered to its motion under these conditions. To go astern the ahead steam valve is closed, and the astern valve opened, admitting the steam from the boilers to the reversing turbine, and reversing the direction of rotation of the inner screw shaft. On the other side of the vessel the arrangement is the same, and it will be seen that she can be maneuvered as an ordinary twin-screw vessel, and with great facility.

The Viper, with full trial weights on board, and a displacement of 370 tons, attained a mean speed of 36.581 knots on a one hour's full-power trial, the mean revolutions per minute being 1,180, and the mean air pressure 4½ in. The speed of 36.581 knots, or nearly 42 statute miles, represents about 11,500 I. H. P. in a vessel of 370 tons displacement, as compared with 6,000 to 6,500 developed in the 30-knot destroyers of similar dimensions and about 310 tons displacement. At all speeds there was an almost complete absence of vibration. Her guaranteed speed astern of 15½ knots was realized.

The Viper passed all her official trials and fulfilled all the guarantees of her contract. As regards speed she exceeded the 31 knots guaranteed, by over 5 knots; and as regards the guarantee of 2.5 lbs. of coal per indicated horse power per hour at 31 knots, she easily obtained a consumption of 2.38 lbs. No guarantees of coal consumption at reduced speed were asked for in the contract. The machinery of the Cobra was similar in size and power to that of the Viper, and she completed her official trials off the Tyne. The turbines in these two vessels, after the first adjustments had been made, worked most satisfactorily and with an immunity from trouble quite unknown with the reciprocating machinery of similar vessels.

It seems necessary to state that the loss of these two vessels (the former being unfortunately accompanied by the death of many of the chief members of the Wallsend staff, as well as of nearly the whole of the navigating party) cannot be attributed in the remotest degree to the fact that they were propelled by turbines. Some persons, however, have raised the question of gyroscopic force, but all such questions had been most carefully calculated before the machinery was designed—for instance, and to show how absurd and groundless such suggestions have been, it may be stated as an illustration, that the actual gyroscopic forces on the bearings of the Cobra's engines, when making 1,100 revolutions at 34 knots, and in the heaviest and shortest sea, could not exceed one-half of the normal weight on these bearings, and at the speed of 18 knots, which was never exceeded on her ill-fated voyage, the gyroscopic forces thrown on the hull could not exceed those produced by one person in walking about the deck.

More could be said as to the absence of reciprocating forces to shake the structure of the hull, but this seems unnecessary, and we pass on to consider the first passenger vessel to be propelled by steam turbines, the King Edward, built in the spring of 1901 by Messrs. W. Denny & Bros. of Dumbarton, and engined by the Parsons Marine Steam Turbine Co., to the order of Capt. John Williamson of Glasgow. She is 250 ft. in length and 30 ft. beam, and about 6 ft. draught of water. The turbines are similar in construction to those of the Turbinia, and consists of three turbines, one high-pressure driving the center shaft, and two low pressures, working in parallel, driving the side shafts; in the exhaust casing of each of the low-pressure turbines is placed the reversing turbine. On the center shaft is one propeller 57 in. diameter, and

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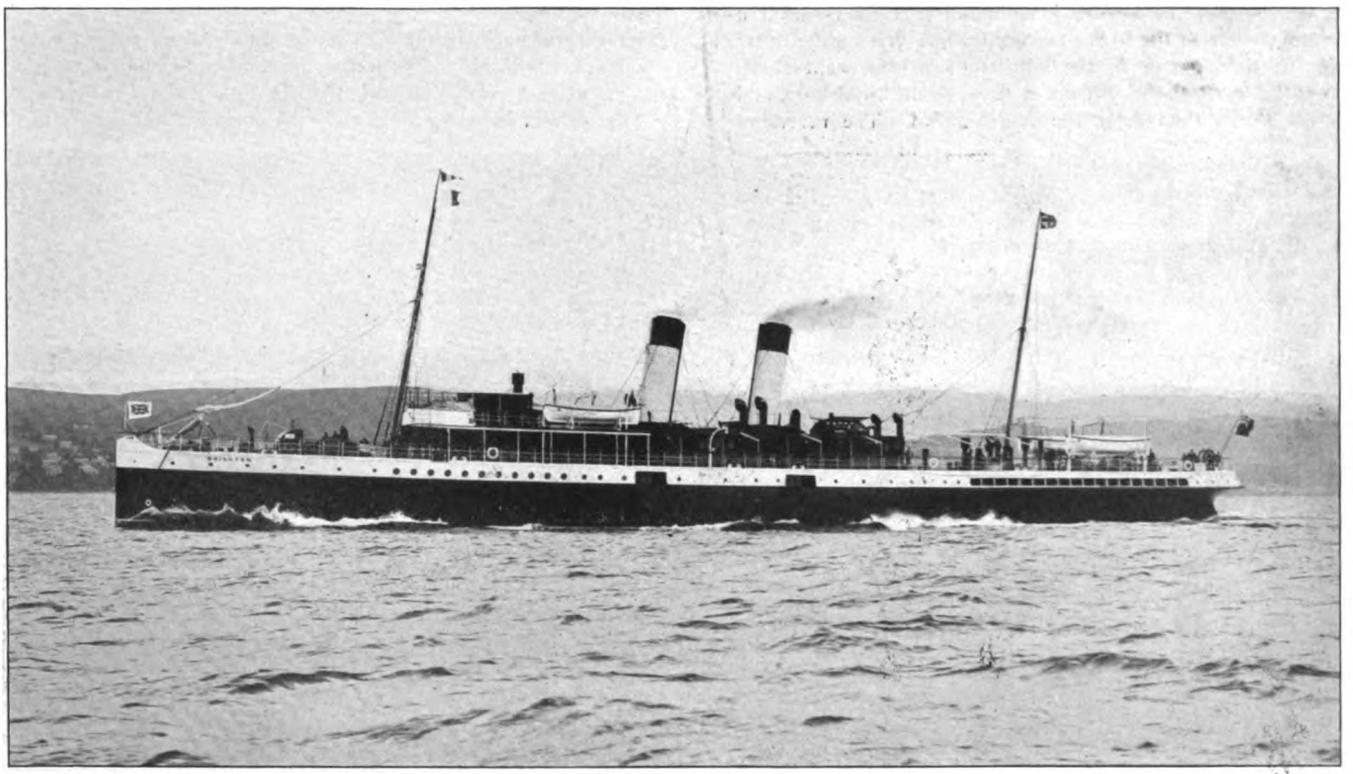
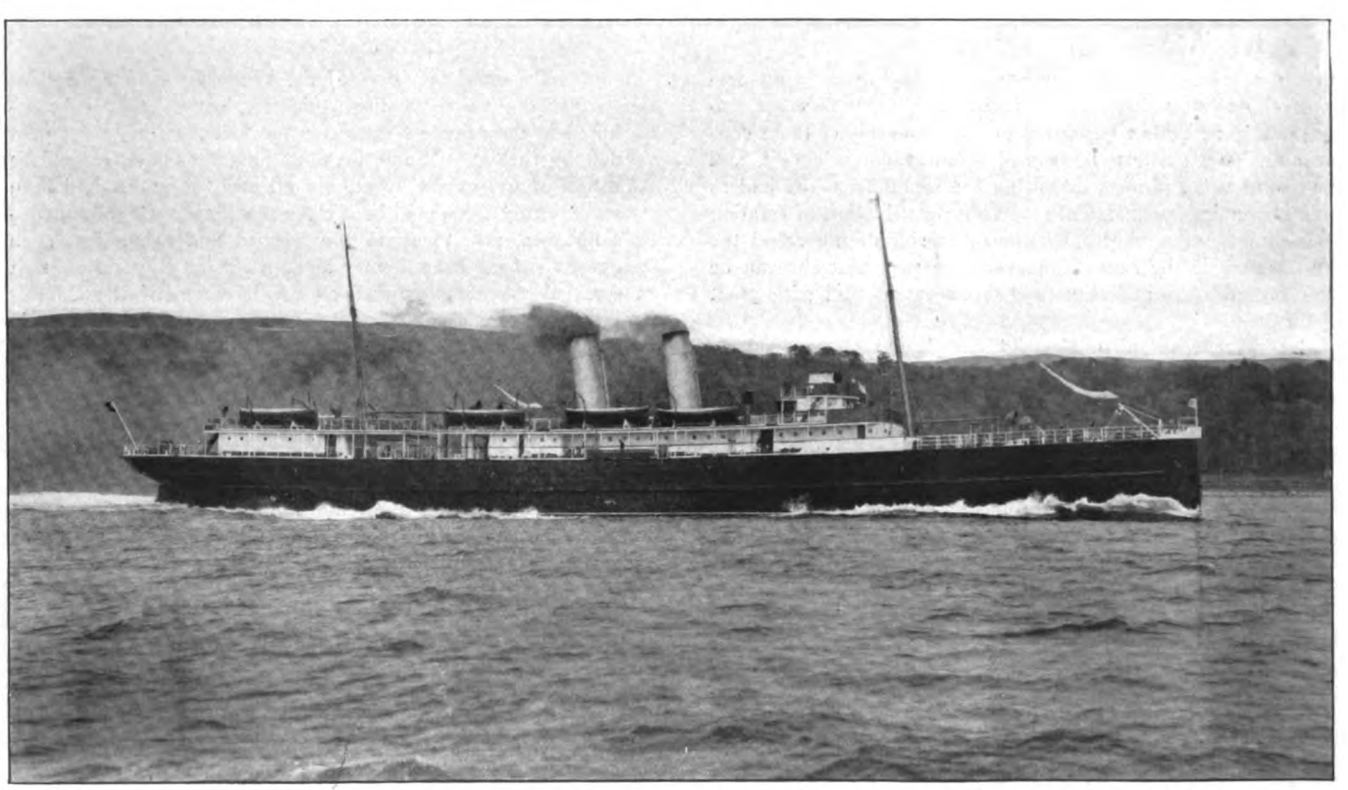


BRIGHTON, TURBINE STEAMER.

[*Built by William Denny & Bros., Dumbarton, Scotland.*

on each of the side shafts are two propellers of 40 in. diameter and about 9 ft. apart. When maneuvering, steam is admitted by valves directly into the low-pressure, or, alternatively, to the reversing turbine for going ahead or astern on either side of the vessel, the center shaft and turbine meantime remaining idle; when the main stop valve is opened to the high-pressure turbine, all the turbines go ahead. The auxiliary machinery is of the usual type, and needs no special mention, beyond stating that the air pumps are worked by worm wheels from the low-pressure turbine shafts. The boiler is of the usual return-tube and double-ended type, and 150 lbs. working pressure.



TURBINE STEAMER PRINCESS MAUD.

[*Built by Wm. Denny & Bro., Dumbarton, Scotland.*

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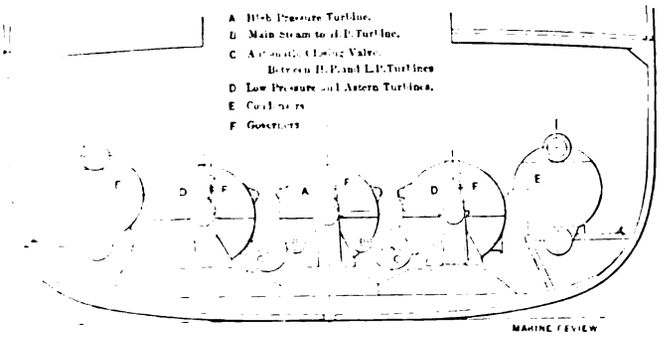
The trial of the King Edward was made on June 26, 1901 on the Clyde, and on the Skelmorlie mile a mean speed of 20.48 knots was recorded, the revolutions of the center shaft being 745, and the side shafts 755.

The indicated horsepower was estimated to be 3,500 from model experiments in the tank at Dumbarton. The average sea speed on the run of about 100 miles to Campbeltown and back in the 1901 season was 19 knots, and the average coal consumption, including lighting up, etc., was 18 tons per day, or 1.8 lbs per equivalent indicated horsepower hour. The results of speed and coal consumption have been stated by Messrs. Denny to be more favorable than those that could have been obtained from a similar vessel with triple expansion reciprocating engines.

An interesting statement has been made by Mr. James Denny to the effect that if the King Edward had been fitted with balanced triple expansion engines of the most improved type and of such size as would consume all the steam the existing boiler could make, the best speed that they could reasonably expect would be 19.7 knots as against the 20½ knots actually attained by the King Edward. The difference between 19.7 knots and 20½ knots corresponds to a gain in indicated horsepower in favor of the turbine steamer of 20 per cent. The performance of the vessel during the seasons of 1901 and 1902 has been most satisfactory, no hitch or trouble having been experienced from the machinery.

In 1902 the second turbine passenger vessel, the Queen Alexandra, was built by Messrs. W. Denny & Bros. for Capt. John Williamson, and engined by the Parsons Marine Steam Turbine Co. Her dimensions are 270 ft. length, 32 ft. beam, and about 6 ft. 6 in. draught. Her machinery is similar



CROSS SECTION OF NEW TURBINE STEAMER SHOWING END VIEW OF TURBINES.

but more powerful, than that of the King Edward. A change was also made in the working of the air pumps from reciprocating engines instead of from the turbines.

The Queen Alexandra had a slightly larger boiler than the King Edward, but the steam pressure is the same, viz., 150 lbs. The Queen Alexandra attained on trial a mean speed of 21.13 knots, the revolutions of the center shaft were 750, and of the side shafts, 1,060. The indicated horsepower taken from Messrs. Denny's tank experiments was estimated to be 4,000, and the consumption of steam was under 15 lbs. per indicated horsepower. In the spring of this year the tandem screw propellers were replaced by single propellers of large diameter and somewhat finer pitch, which has had a beneficial effect in greater smoothness of motion, and a slight improvement in the speed and coal consumption. The success of these two turbine vessels has led to the adoption of turbines for the latest vessels for the Dover-Calais and the Newhaven-Dieppe services, and these fine vessels constitute a very important step in advance for marine steam turbine machinery.

The Dover-Calais boat Queen, for the South Eastern & Chatham Railway Co., is 310 ft. in length, 40 ft. beam, and 25 ft. depth. The machinery is designed for 8,000 I. H. P. on service. The trial of the Queen took place on June 12, 1903, on the Skelmorlie mile, when the mean speed of 21.73 knots was easily attained, which was considerably over the speed guaranteed by Messrs. W. Denny & Bros. When steaming continuously astern the mean speed of 12.95 knots was obtained. Stopping and starting trials were also carried out, and the vessel, from a speed of slightly over 19 knots, was brought to a dead stop in 1 minute 7 seconds, and she traveled during this time 130 fathoms, or two and a half times her own length.

The Newhaven-Dieppe boat, for the London, Brighton & South Coast railway, is 280 ft. in length, 34 ft. beam, and 22 ft. depth. This vessel was launched on the 13th of June and it is to be expected that she will be ready for her trials in a few weeks.

Three yachts have lately been fitted with steam turbines. The largest is the Lorena, built by Messrs. Ramage & Ferguson, Ltd., of Leith, to the order of Mr. A. L. Barber, of New York, and to the designs of Messrs. Cox & King of London. This vessel is 253 ft. in length on water line, 33.3 ft. beam and about 13 ft. draught of water. The turbines are similar to those of the King Edward and Queen Alexandra, but somewhat larger, and designed for a speed of vessel of 16 knots. She is fitted with four single-ended Scotch boilers of 180 lbs. pressure, with a total heating surface of 8,560 sq. ft., and grate surface of 217 sq. ft., with Howden's forced draft. The adoption of turbines instead of reciprocating engines as originally contemplated permitted of a considerable increase of the saloon accommodation, besides saving 70 tons in the weight of the machinery.

The Lorena's trial took place in Aberlady Bay in the Firth of Forth, on May 16, and, after several runs over the measured mile, the mean speed attained was 18.62 knots. The number of revolutions on the center shaft was 550, and of the side shafts 700. The machinery was kept running at full speed over five hours, and worked with the utmost smoothness. From observations taken on the trial it was found that she will be very economical in coal consumption, and further trials of coal and water consumption are contemplated previous to her leaving for New York. The above full-speed trial was run with the vessel in normal cruising conditions at sea with about 240 tons of coal on board, or about half bunkers.

The steam yacht Emerald, built by Messrs. Alex. Stephen & Sons, Ltd., of Glasgow, to the order of Sir Christopher Furness, M. P., has been the first vessel propelled by turbines to cross the Atlantic. Her dimensions are: length, 198 ft.; beam, 28 ft. 7 in.; and displacement about 600 tons. Her turbine machinery is also similar to that of the two Clyde vessels, and she has one Scotch boiler with Howden's forced draft. She is fitted with one propeller on each shaft. She attained a mean speed of 15 knots on trial. The smoothness of running of the machinery and propellers is a noticeable feature. In crossing the Atlantic at the end of April she experienced very severe weather and head winds, but the propellers never raced and the machinery worked admirably and without the slightest hitch.

The turbine yacht Tarantula, built by Messrs. Yarrow for the late Col. McCalmont, is similar in dimensions to a British first-class torpedo boat, but of heavier scantlings. Her turbine machinery is similar to that of the Turbinia, but she has in addition a cruising turbine to increase the economy at speeds up to 15 knots. On trial she reached a mean speed of 25.30 knots on a displacement of 150 tons. This speed could probably have been increased by the substitution of single instead of tandem propellers, but she passed out of our hands before the probable benefit of such a change had been ascertained.

The Velox, a torpedo-boat destroyer built by Messrs. Hawthorn, Leslie & Co., for the Parsons Marine Steam Turbine Co., and recently purchased by the British admiralty, is

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fitted with machinery of the same power as that in the Viper, and, on emergency, capable of developing upwards of 10,000 I. H. P. A noticeable feature in this vessel is that two triple expansion reciprocating engines are fitted, of 150 I. H. P. each, connected by detachable claw couplings to the low-pressure turbine shafts. At cruising speeds up to 13 knots, steam, after working these engines, exhausts into the turbines, where its expansion is completed before passing to the condensers The displacement when fully laden on trials was 440 tons. The consumption of coal at 27 knots worked out at 2.501 lbs. per indicated horsepower, and at 11¼ knots 8½ cwts. per hour. At a speed of 31 knots, the estimated consumption would be about 2.3 lbs. per indicated horsepower.

The very slow progress of the marine steam turbine at a time when the turbine was making rapid strides on land may seem somewhat remarkable, but it has been due to causes sufficiently obvious to all who have given attention to the subject. The Turbinia company, in 1897, directed their special

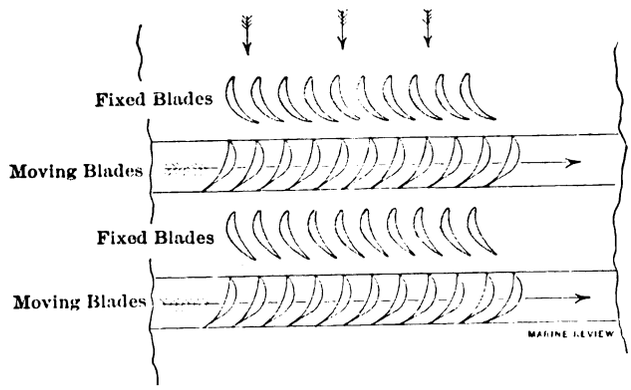

FIG. A. BLADES.

and almost exclusive attention to the introduction of the turbine in destroyers as the most suitable and favorable application among all classes of vessels. Their efforts met with remarkable success in the direction of increased speed and diminished vibration, and immunity from breakdowns, and good economy at the higher rates of speed, but the very great delays and the immense difficulties and expense of carrying through such contracts, incidental to the introduction of a new class of machinery, and concluding by the total loss of the only two sets of machinery made at this period (other than the original Turbinia), had a very detrimental effect on the introduction of turbine machinery generally.

Now, after six years of unremitting work by a highly skilled and devoted staff, and the expenditure of much money by the company, there is no turbine-propelled vessel actually in commission in the British admiralty service, though three turbine vessels are about to go into commission. Both the Viper and Cobra were unfortunately lost before substantial practical experience in commission had been obtained. During and after the occurrence of these events, the Turbine company directed their attention to the important application of their system to vessels of moderate speeds, and their efforts in this direction have met with much encouragement and great success. The names of Capt. John Williamson, the managing owner, and Messrs. Denny, the builders, will ever be associated with the King Edward, the first passenger vessel to be propelled by steam turbines. The vessels, King Edward, Queen Alexandra and Queen, and the yachts Lorena, Emerald, Tarantula are now in commission, and have given entire satisfaction to the owners and the public.

The engining of larger vessels and liners is not a very long step beyond what has already been proved to be successful. The experience with the marine turbine up to 10,000 H. P. in ships of fast as well as moderate speed, has tended to justify the anticipation guided by theory that the larger the engine the more favorable will be the results as compared with reciprocating engines. The saving of weight, cost, space, attendance and upkeep will become still more marked with turbine engines of above 10,000 and up to 60,000 H. P., for which designs have been prepared.

APPENDIX BY PROF. J. A. EWING.

The Turbinia is 100 ft. in length, of 9 ft. beam, and had a displacement under the trial conditions of about 44½ tons. has three screw shafts, each of which is directly driven by one of Parsons' steam turbines. The turbines are of the parallel flow type, the general course of the steam through them being parallel to the axis of rotation. In each of the three turbines steam enters at the forward end, and streams aft through an annular space formed between the outside of a cylindrical boss, which is carried by the shaft, and the inside of a corresponding cylindrical casing, in which the turbine is enclosed. In streaming through this space, the steam passes alternate rings of fixed guide blades and moving turbine blades. The guide blades are fixed on the inside of the casing, and project radially inwards. The turbine blades project outwards from a hollow casing, which forms the boss. The fixed and moving blades have the same shape: their relative position is indicated in the sketch (Fig. A). As the steam passes from ring to ring its pressure falls and its volume increases. The blades are therefore spaced more openly from one ring to the next, and further, each turbine is stepped about the middle of its length, the casing there being enlarged to allow the blades to be longer in the after part.

The three turbines form a compound series, steam being first admitted to the turbine on the starboard side, passing thence to the turbine on the port side, and, lastly, to the low-pressure turbine, which is placed amidships. The speed is controlled by a throttle valve on the admission pipe to the high-pressure turbine. When running at full power the admission pressure is about 155 lbs. by gauge, or 170 lbs. absolute, and this was reduced by expansion in the turbine to about 1 lb. per square inch before the steam was discharged to the condenser. The position of the turbine and the general arrangement of the machinery are shown in Figs. 1 to 4. Fig. 1 is a midship section of the boat, from the forward stokehold to the stern; Fig. 2 is a corresponding sectional plan. Fig. 3 is a transverse section through the forward end of the engine room, looking aft. Fig. 4 is a section showing the high-pressure, intermediate and low-pressure turbines. Fig. 5 is a transverse section through the forward stokehold. Fig. 6 is a section at the after end of the vessel showing the propellers.

From the low-pressure turbine, steam is taken by a large exhaust pipe to a pair of cylindrical surface condensers, with a total cooling surface of 4,200 sq. ft., through the tubes of which a circulation of sea water is kept up by means of hinged scoops projecting from the sides of the boat. The scoops may be set to make water enter at either side and pass out at the other, so that any obstruction to the flow may be cleared by reversing the direction of the stream. The air pump is a small reciprocating pump, which appears in the plan on the port side.

The turbine shafts slope down towards the stern, the middle shaft with an inclination of about 1 in 16, and the two side shafts with an inclination of about 1 in 8½. Their diameter is 2½ in. There are three propellers on each shaft, making nine in all, which are distributed as shown in the plan. The screws are 18 in. in diameter and 2 ft. in pitch. When running at full speed they make about 2,200 revolutions per minute.

The middle shaft projects forward through the low-pressure turbine, and has mounted on it a fan for forcing the draft. Air is delivered by this fan into the after stokehold, and passes to the forward stokehold, round the sides of the boiler. The air pressure at full speed is about 7 in. by water gauge. The boiler is double ended, of the water-tube type, with straight tubes and large external return tubes. It has a heat-

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ing surface of 1,100 sq. ft., with 42 sq. ft. of grate. Steam is supplied at the working pressure of 210 lbs.

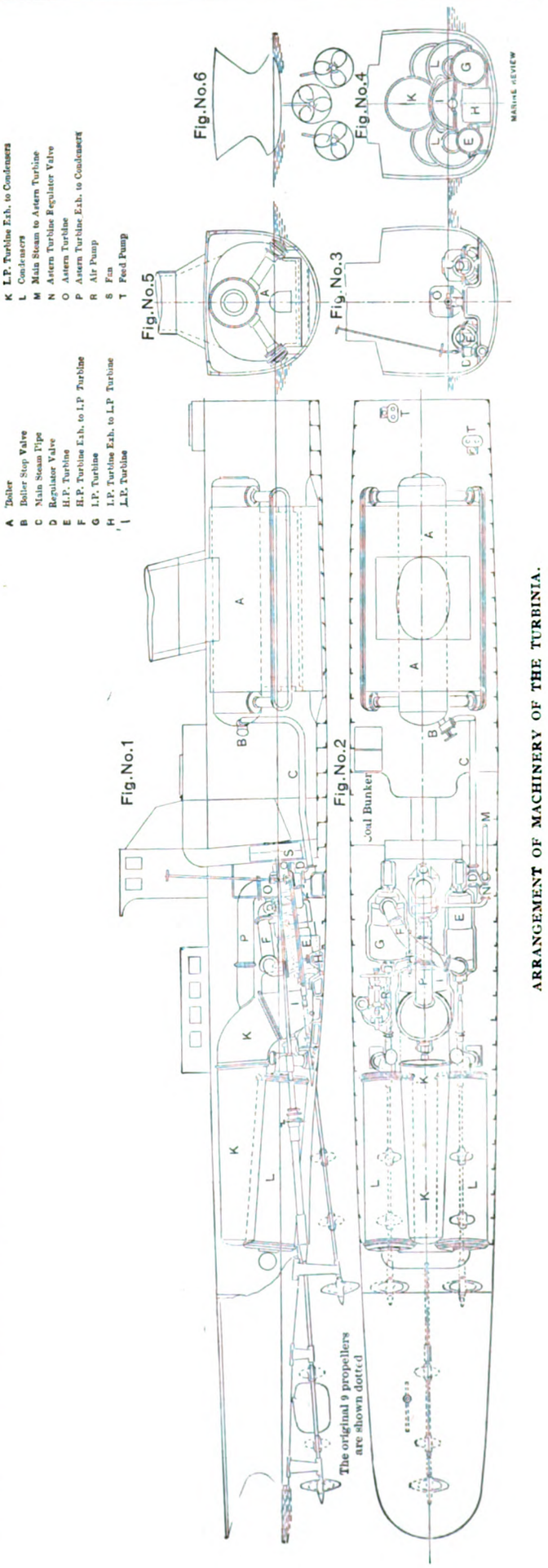
The auxiliary machinery consists, in addition to the air pump, of a small spare air pump, small circulating pump for use when the scoops are not available, main and spare feed pumps, bilge ejector, and oil pump for maintaining a circulation of oil through the bearings of the turbine shafts and through the thrust blocks. There is a thrust block enclosed within the casing at the forward end of each of the three turbines, consisting of a series of rings projecting from a fixed sleeve into grooves turned on the shaft. The thrust to be taken by each block is, however, only a small fraction of the thrust exerted by the corresponding shaft. The greater portion is taken by the turbine casing, on account of the action of the steam on the blades. Each ring of blades has a greater pressure in front than behind, and the forward end of the central boss has a much greater pressure than the after end. Thus the total excess pressure forcing the turbine aft would be greater than the thrust of the shaft forcing it forward, were it not that a dummy or balance disc is introduced, the back of which is exposed to steam at the pressure of its admission to the turbine; while in front there is a chamber connected with the exhaust. Steam is prevented from leaking past by giving the dummy a long cylindrical surface with grooves turned in it, into which rings in the casing project. The dummy is so proportioned as to make the resulting steam thrust nearly balance the propeller thrust, leaving only a comparatively small difference to be taken by the thrust block.

At each end of each turbine the shaft passes through a gland and is carried in a bearing formed by three concentric cylindrical sleeves fitting loosely one within the other, and enclosing between them films of oil, which is continuously fed to the bearing under pressure. The gland is formed by a long series of grooves round the shaft, revolving in a grooved brass bush. Live steam is admitted to a lantern in the gland, so that no leakage can have the effect of letting air be drawn in. By adjusting the pressure at which steam is supplied to the lantern, the leakage of steam outwards is almost absolutely prevented. Although the draught is only three feet, the high-pressure and intermediate turbines lie well below the water-line. The top of the casing of the low-pressure turbine and the connecting pipe between the high and intermediate turbines project slightly above it. The exhaust pipe and part of the condenser also projects.

The machinery is for its power extraordinary light and compact. Its low position has an advantage from the point of view of stability, and, along with its small bulk, leaves the engine room remarkably clear. The turbines being completely enclosed, the running parts are well protected from damage.

For the purpose of reversing the motion, a separate turbine is provided between the low-pressure turbine and the fan. This was being made and was not in place at the time of the trials. I was therefore unable to make any trials of the speed attained in going astern. When the boat is going ahead, this reversing turbine, being permanently mounted on the central propeller shaft, will revolve, but its casing will be kept connected to the condenser, and the amount of work spent in turning it will be insignificant.

The mechanical friction of the turbines is particularly small, and the work spent on friction is not materially increased by increasing the range of expansion. This allows the steam to be profitably expanded much farther than would be useful or even practicable in an engine of the ordinary kind. Apart from questions of friction, the addition of weight and bulk to allow for this extended expansion would be enormous in the ordinary engine. In the turbine it is very moderate. Steam is expanded nearly two-hundredfold in the Turbinia and this is accomplished with engines which are much lighter than reciprocating engines of the same power, although in these the expansion would be much less complete.



ARRANGEMENT OF MACHINERY OF THE TURBINIA.

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DEVOTED TO EVERYTHING AND EVERY INTEREST CONNECTED OR ASSOCIATED WITH MARINE MATTERS ON THE FACE OF THE EARTH.

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JULY 7, 1904.

If anyone is looking for the turbine as a means of marine propulsion in the United States he will not find it. So far only one vessel, and that an experimental one, the Revolution, has been fitted with a Curtis steam turbine and this is all. It is not yet definitely decided as to whether the navy department will equip any one of the scout cruisers authorized by congress with turbines, though congress has authorized the department to do so if it deems it advisable. The subject is under debate in the bureau of steam engineering but no decision has been reached on it. So far four ships equipped with turbine engines have appeared in American waters. The first was the Emerald, a steam yacht built for Christopher Furness and chartered last season by Mr. George Gould. The second was the Tarantula, purchased by Mr. W. K. Vanderbilt, the third was the Lorena owned by Mr. A. L. Barber of New York, and the fourth is the Turbinia owned by the Turbine Steamship Co. of Hamilton, Ont., and intended for service on Lake Ontario between the ports of Hamilton and Toronto. While it is not authenticated it is understood that the speed of the Turbinia has approached 29 miles an hour, which would make her the fastest steamer on the great lakes by all odds. It is expected that the Victorian of the Allan Line, equipped with turbines, will in about six weeks make her maiden trip to Montreal.

With the exception of the little experimental vessel Revolution the application of the turbine to marine propulsion is exclusively British, and all of them have been fitted with the Parsons make of turbine. Mr. Charles A. Parsons, who is a son of Lord Rosse of telescope fame, is a great mechanical genius and has been developing his form of turbine ever since 1884. Elsewhere in this issue will be found a description of the little Turbinia, which was the first vessel to be fitted with turbines by him. The first turbine steamer for commercial use was the King Edward, launched on the Clyde in 1901 for river service. She was followed by the Queen Alexandra, also for river service, and later turbine steamers were put in the cross-channel trade with eminent success. These steamers were all built by Wm. Denny & Bros., Dumbarton, Scotland, and equipped with engines by the Parsons Steam Turbine Co. Turbine steamers for the trade between Australia and New Zealand have also been built by Denny & Bros. Workman, Clarke & Co., Belfast, Ireland, are building the Victorian for the Allan Line, and Alexander Stephens & Son., Glasgow, are building the other. John Brown & Co., Clydebank, Scotland, and Swan & Hunter, Wallsend-on-Tyne, are to build the two great turbine steamers for the Cunard Steamship Co. under subvention from the British government. The fact that these two great liners are to be equipped with this form of engine is by far the most significant thing which has occurred in the development of this type. The whole engineering world is deeply interested in this enterprise and it has been undertaken by the Cunard company only after the most expert research and the utmost deliberation.

But while American makers have as yet done practically nothing towards the development of the turbine for marine purposes they have been highly successful in developing it for stationary uses. It is a significant circumstance that the greatest engine builders in the United States are engaging in turbine construction. One engineering company has turbines to the extent of over 250,000 H. P. under construction and another has almost as much with 50,000 H. P. in daily operation. The Parsons type of turbine which is a horizontal turbine is being built in the United States by the Westinghouse Machine Co. of Pittsburg, who have made a number of improvements in its construction. The Curtis steam turbine is built by the General Electric Co. of Schenectady, N. Y. It is a vertical turbine. A third type is the De Laval, which is made by the De Laval Steam Turbine Co. of New York and by companies associated with it in other parts of the world. It is a horizontal turbine but differs widely in construction from the Parsons. It is not built in large units, being seldom constructed in sizes over 300 H. P. It is a very successful device, however, many hundreds of them being used in the

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United States. The De Laval people have applied the principles of their turbines to cream separators, of which it is understood they have half a million at work in the United States. These three are the turbines best known in this country. The Allis-Chalmers Co., foremost as builders of reciprocating engines, are bringing out a turbine similar to the Parsons but embodying certain notable departures. In Europe in addition to the Parsons turbines best known are the Zoelly, the Rateau and the Zoelly. They are all of the horizontal type.

The chief advantages of the turbine are its simplicity and durability. While in piston engines there are many parts that wear there is practically nothing to wear out in the turbine. The only rubbing parts are the bearings at each end of the spindle. These bearings run in oil and after years of service show literally no wear. Another advantage, which is important on shore but vital aboard ship, is its saving of space. With all these advantages, however, various high authorities in the engineering profession are approaching the turbine with great caution and are inclined to think that a number of years will yet elapse before it will have passed the experimental stage. However, there is nothing but unbounded admiration for those who have been unremitting in their labor, to bring the turbine to its present stage of development.

Any movement which tends to divert the export trade from southern ports to the port of New York tends to increase the general traffic of the great lakes, for western products destined for export via New York would naturally travel part way over the cheapest route, which is, of course, the great lakes. Therefore the present campaign which the merchants of New York are making against the differential allowed southern ports by the railroads for export trade meets with cordial approval in the great lakes region.

"THE MAN AT THE WHEEL."

[illegible]

[illegible] the Illinois Manufacturers' association desires to place [illegible] record as favoring by all feasible and legitimate [illegible] upbuilding of the American merchant marine and [illegible] restoring of the American flag to the ocean highways of [illegible]"

[illegible] was the resolution unanimously adopted by those in [illegible] at the banquet given by the Illinois Manufacturers' [illegible] at the Auditorium hotel in Chicago on the evening [illegible] June 24, after listening to a number of addresses [illegible] subject of our merchant marine by those present.

[illegible] those who voted for the resolution meant it too, and [illegible] it with a shout that testified to their sincerity and [illegible] emphatically effective.

[illegible] fun of it was that this audience was at the beginning [illegible] like any other audience of American citizens who [illegible] come together to hear this subject discussed.

[illegible] could have been said to have been in any way well informed [illegible]

[illegible] a canvass made before the addresses were delivered would have revealed the fact that the great majority were adverse to giving any assistance to the building up of our merchant marine in the foreign trade.

But their prejudices were swept away very quickly when the exact truth was fully explained to them.

Then somebody presented the resolution.

It was seconded by a score of those present.

The chair put the motion and the result is a matter of record.

Of course the resolution itself is indefinite as to the means to be adopted, but in view of the many conflicting ideas advocated, nothing else could have been expected or desired.

It is therefore a unanimous expression of feeling on the part of those present that they favor some sort of national assistance, leaving it to congress to evolve the method.

And what was done on that occasion by those present will be repeated by every body of business men who have an opportunity of hearing the truth.

No question about it.

Just give them a chance.

There will never be any minority vote when American business men and American citizens get the exact facts.

They will simply make it unanimous every time.

Only give them the facts.

Funny thing about this commisison though.

They were authorized by congress to listen to any statements that anyone might desire to make—statements from ship builders, ship owners, disinterested citizens or anyone employed in any capacity in marine matters.

In fact it was intended that they should listen to statements and secure information from all available sources bearing in any way directly or indirectly upon this subject.

And at the beginning they had in mind some half dozen or dozen hearings of perhaps a day each in as many different localities.

But what a difference.

Invitations to the commission from business men's associations and chambers of commerce in many different sections between the Atlantic and the Pacific have been received, and if the commission were to attempt to accept them, together with those that might be received later on if it were felt they might be accepted, it is doubtful if they would get through this year.

This just simply indicates the existence of a greatly increased measure of interest and the fact that people are beginning to realize that not alone our shipping interests are suffering, but as a result, our entire foreign trade, and therefore the whole country at large.

And that is all there is to it, practically.

Bring that lesson to the American people and they are very likely to put the proper machinery into motion without any delay.

But in their visits to Chicago, Detroit and Cleveland, the commission were treated to many surprises.

For instance, in Detroit, among very many valuable suggestions as recorded in our issue of June 30, was an exceedingly interesting paper from Mr. H. T. Morley, who is interested in both lake and sea-going commerce and who has made a study of it in both localities.

Mr. Morley pointed out the indifference of our law-makers to our marine interests and the easy manner in which they gave away concessions of the very greatest value to the entire country, unless they were constantly watched and checked up.

Prominent members of the commission admitted that they had entirely overlooked the gigantic possibilities to our merchant marine involved in the Cuban reciprocity treaty recently put into effect, and that it would have been quite easy to have

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included in the treaty certain provisions that would practically have extended our coast laws to Cuba.

This trifling concession would have been enough to have kept every ship yard on the coast busy for years and to have inaugurated the expenditure of millions of dollars for ships which would have been distributed all over the United States in hundreds of localities, from the mines to the work-shops in almost every city where are manufactured supplies or articles used in the construction of the modern steel ship.

It would likewise have given employment to hundreds of those idle American ships which now fill the harbors on both coasts.

What is more, the lake ship yards would have received their share of the business, as the great majority of steam vessels now engaged in the fruit and other trades between Cuba, Porto Rico, Jamaica and the West Indian islands are less than 256 ft. in length (canal size), and could be profitably and expeditiously built at Cleveland, Toledo, Detroit, Chicago or Duluth.

As between one and two hundred of these ships would have been very promptly required, some idea of the value of this business to the United States may be easily formed.

As it is now, owing to the inertia, oversight, indifference, negligence or something worse, of our national legislators, this large marine industry is handled almost entirely in vessels carrying the flag of Great Britain, Norway or Germany, etc., and millions of good hard American dollars for ship construction, wages, freight charges, etc., are yearly sent out of the country.

If just a little effort had been made, therefore, to protect our marine interests as well as every other in this respect, without any great cost or subsidy legislation, a different story could be told about one very important part of our merchant marine trade.

It is estimated that the price paid by the people of the United States for Cuban reciprocity amounts to about $10,000,000 yearly.

In addition to that we have spent over $250,000,000 to assist Cuba, and all it would have required on the part of our national legislators when the treaty was under consideration would nave been to have requested in return some little concession to our merchant marine, and the request would undoubtedly have been granted without any hesitation.

But "no one ever thought of it," as one of the senatorial members of the merchant marine commission said, until it was too late.

And there you are.

Surely when we are so generous always and upon every opportunity to foreign nations we might be just a little just to ourselves.

Then when the commission reached Cleveland they had other surprises.

Perhaps the greatest of all came from A. B. Wolvin in explaining the reasons why one of the companies of which he is manager had found it so advantageous to charter a couple of steamships carrying the Swedish flag for their lake trade. This company is known as the Great Lakes & St. Lawrence Transportation Co., operating ten modern steel steamers between Duluth and Montreal, stopping at intervening points, and with the addition of the two Swedish vessels the present size of their fleet is twelve, all told.

Mr. Wolvin pointed out that he had chartered and operated these ships for this trade at a sum that made the expense of operating the ships of the line that carried the American flag extremely expensive in comparison.

One of the chief reasons for this is shown in the wages paid on the Swedish ship on the same route, in the same trade exactly, and under the same conditions.

To begin with, the regulations of the various unions represented in American vessels make it compulsory that twenty-one men should be carried, while the Swedish ship carries and gets along very satisfactorily with only seventeen.

We give below the wages paid per month by the owners of the Swedish ships compared with the amount paid on American ships of exactly similar size as far as comparisons can be made:

	Swedish vessel. Kroner.			American vessel.
Captain, per mo.	300	equals	$79.50	$175.00
First mate, per mo.	120	"	31.80	100.00
Second mate, per mo.	90	"	23.85	70.00
First engineer, per mo.	180	"	47.70	125.00
Second engineer, per mo.	130	"	34.50	90.00
Steward, per mo.	75	"	19.97	60.00
Cook, per mo.	60	"	15.90	30.00
Carpenter, per mo.	65	"	17.25	.....
One A1 seaman, per mo.	60	"	15.90	45.00
Two A1 seamen, per mo.	55	"	14.57	45.00
Two A1 seamen, per mo.	50	"	13.75	25.00
One A1 seaman, per mo.	35	"	9.27	.....
Donkeyman, per mo.	65	"	17.22	25.00
Three firemen, per mo.	60	"	15.90	42.50

The contrast is so great as to carry with it its own lesson.

And that is not all.

Mr. Wolvin says that the difference in expense is so great that that company may find it to their advantage next year to employ ten or twenty or even as many as thirty Swedish vessels of this size for the grain and package freight business between Duluth, Montreal and intermediate points.

Just think of it.

This will throw out of the present trade an equal number of American vessels which would have to find business elsewhere.

Resolved into its original elements this means that the foreign ship is about to become a competitor for business on the Great Lakes to the injury of the Great Lakes owners and ship yards, the manufacturers of steel plate, hoisting and electrical machinery, ventilating apparatus, and the myriads of other component parts that enter into the construction of the modern ship.

It means the throwing out of employment of thousands of American workmen in all parts of the country. It means the throwing out of employment of large numbers of Americans who under ordinary circumstances would find employment on the ships of this trade, and it means lower and more severe conditions all along the line.

And yet there are some newspapers on the Great Lakes and elsewhere that have been holding up to scorn the work of the Merchant Marine Commission and its efforts to get at the exact facts with a view of endeavoring to apply a remedy.

Some of these newspapers have likewise, from their exalted position of superior knowledge, been loudly proclaiming that the marine interests of the Great Lakes had nothing to fear and that the commission ought to stay at home or stay away from this territory.

And yet this question of the foreign ship is only one of a large number of other surprising pieces of information which the commission gathered which were not previously understood and which are of sufficient importance of themselves to justify the appointment of this commission and the work it has undertaken.

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LAKE FREIGHT SITUATION.

The ore shipments to June 1 of the present year were 7,243 tons. To July 1 they were 1,707,726 tons as against shipments aggregating 8,237,929 tons to July 1, 1903, a falling off of 6,530,303 tons for the present year. The movement during June is to be credited to the last half of the month as it was June 14 before the strike of the masters and pilots was declared off and it was some days later before the vessels were actually in commission. Even then the shipping docks were not prepared to receive them. The movement during June of last year was 3,716,353 tons, so that the movement during June of this year was proportionately as good. After July 1 of last year about 15,000,000 tons were moved so that if the total movement reaches 16,000,000 tons this year the vessels will be kept reasonably well employed. The freight rate last year was 85 cents from the head of the lakes. So far this year vessel owners have been unable to force it above 70 cents, though there is not much season contract ore covered at that figure.

The double holiday of Sunday and Monday did not congest Lake Erie docks as badly as in former years. Every effort was made to get the vessels out Saturday and they passed up the rivers on Sunday in a constant stream. The docks are indeed in excellent shape and some of them were even looking for business on Thursday morning. The docks at the head of the lakes are somewhat congested but not seriously so.

LAKE CARGO RECORDS.

Lake cargo records have again been broken by the great steamer Augustus B. Wolvin. She took a cargo of 10,569 net tons of anthracite coal from Buffalo to Milwaukee. The Wolvin was given a great reception when she reached the harbor. She was escorted into the harbor by tugs which had gone out several miles into the lake to meet her and a welcoming party on the dock rechristened her by breaking innumerable bottles of the amber fluid that made Milwaukee famous against her huge sides. Occasion was made by the business men present to point out the necessity of additional facilities in the harbor of Milwaukee to accommodate the increasing size of steamers. The reception to the Wolvin was arranged by Edward A. Uhrig, president of the Milwaukee Western Fuel Co. The next trip of the Wolvin will be from Escanaba to South Chicago with ore. On this trip she can load to 20 ft. and it is expected that the size of her cargo will greatly exceed anything ever carried on the lakes.

The steamers J. H. Reed and D. G. Kerr on their initial trips from Duluth this season carried 275,000 bu. of wheat each. This is equivalent to 8,250 net tons and is the cargo record for wheat. Following are the cargo records to date:

Iron Ore—Steamer Augustus B. Wolvin, owned by Acme Steamship Co., A. B. Wolvin, Duluth, manager, 9,727 gross tons or 10,892 net tons, Two Harbors to Lake Erie. Steamer Wm. Edenborn, owned by Pittsburg Steamship Co., A. B. Wolvin of Duluth, manager, 8,867 gross tons or 9,864 net tons, Escanaba to South Chicago.

Grain—Steamers J. H. Reed and D. G. Kerr, Provident Steamship Co., A. B. Wolvin of Duluth, manager, 275,000 bu. of wheat each, equal to 8,250 tons (2,000 lbs.), Duluth to Buffalo; steamer D. M. Clemson, Provident Steamship Co., A. B. Wolvin of Duluth, manager, 330,305 bu. of barley, equal to 9,733 tons, Duluth to Buffalo; steamer Rensselaer, Pittsburg Steamship Co., A. B. Wolvin of Duluth, manager, 151,000 bu. of wheat, 94,000 bu. of barley and 55,155 bu. of oats (300,155 bu. in all), equal to 7,008 tons, Chicago to Buffalo; steamer Nebraska, Pittsburg Steamship Co., A. B. Wolvin of Duluth, manager, 185,309 bu. of corn, 40,000 bu. of rye and 43,600 bu. of wheat (268,909 bu. in all), equal to 7,619 tons, Chicago to Buffalo.

Coal—Steamer Augustus B. Wolvin, owned by Acme Steamship Co., A. B. Wolvin, Duluth, manager, 10,569 net tons of anthracite, Buffalo to Milwaukee; steamer Augustus B. Wolvin, owned by Acme Steamship Co., A. B. Wolvin, Duluth, manager, 9,904 tons, 1,800 lbs. of bituminous, Lorain to Duluth; steamer James H. Reed, owned by Provident Steamship Co., A. B. Wolvin, Duluth, manager, 8,029 tons, 1,400 lbs. of soft coal, Toledo to Duluth.

CHICAGO GRAIN REPORT.

Chicago, July 7.—From last report going rates have been held steady at ¾c corn to Lake Erie ports. The Montreal shipping via all water routing continues at 3½c and 3¾c lake and rail for the same point. The package freight movement shows no immediate betterment and the surplus line vessel space remains restricted to figuring in grain. The cash demand and general movement from western points under indifferent conditions. On the part of vessels very little interest in the market and engagements more or less shape toward the convenient handling of other cargo.

Of the weekly shipments noted below there was via all rail routing some 85,000 wheat, 170,000 corn and 500,000 oats, via lake routing to Buffalo and other American points 70,000 wheat and 900,000 corn, and via lake to Canada points some 200,000 corn.

The following are the weekly figures covering stocks and general shipping movement:

Lake and rail shipments.

	This week.	Last week.	Same week last year.
Wheat	157,844	275,497	211,520
Corn	1,236,281	1,991,566	1,464,035
Oats	579,638	624,183	715,634
	1,973,763	2,891,246	2,391,189

	Shipments since Jan. 1, 1904.	Same week last year.
Wheat	6,758,129	10,536,830
Corn	30,060,992	39,570,168
Oats	23,614,355	33,517,064
	60,442,476	83,624,062

Stocks of grain in elevators.

	Last week.	Same week last year.
Wheat	2,708,000	4,276,000
Corn	6,055,000	7,340,000
Oats	1,348,000	1,765,000
Rye	453,000	203,000
	11,164,000	13,584,000

NEW GRAIN COMPANY.

Duluth, July 6.—The Zenith Grain Co., organized under Canadian laws, has been incorporated with $50,000 capital to do a receiving and shipping business at Winnipeg. Ward Ames, Sr., is president, J. H. Barnes, vice president, Ward Ames, Jr., treasurer, and H. T. Swart, secretary and manager. Mr. Swart will reside in Winnipeg. The others are members of the Ames-Brook Co. of Duluth, the largest exporters in the west and among the largest in the country. Mr. Swart has been elevator agent at Duluth for the Great Northern road, and as such has had charge of its great terminal elevator interests. The Ames-Brooks Co. has been a large exporter of Canadian wheat from Port Arthur and Fort William and is making arrangements to carry on this branch of the trade on a still larger scale.

On the arrival at Duluth on the first trip of the package freighter Duluth, a banquet was given by the Commercial club of the city in honor of the ship. A number of citizens, as well as representatives of the Western Transit Co. and captain

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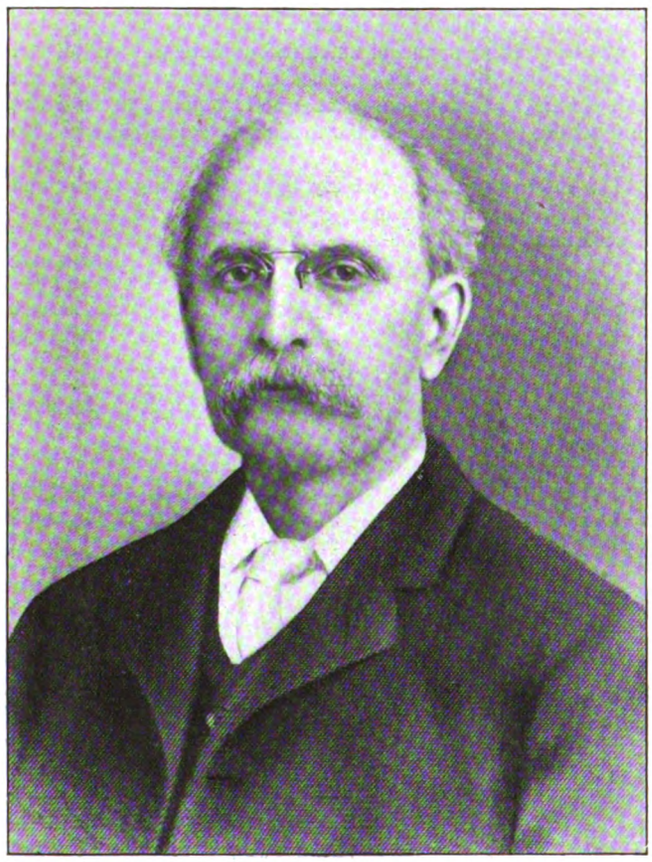
and engineer of the vessel, were present. Numerous speeches were made felicitating the vessel, on being named after the city, and the city on having such a representative, congratulating the company on its enterprise and the city on its importance, in fact the usual run of speeches on such occasions. As is customary, men without much knowledge of special lines of trade and commerce attempted to talk about them, and made the usual laughable blunders. But it was a very nice occasion and was heartily enjoyed. Messrs. Ames and Douglas, who spoke on reciprocity and the Western Transit Co., gave talks with meat in them and were warmly applauded.

FUTURE OF LAKE SHIP BUILDING.

As illustrative of the condition of lake industry the brief testimony of Mr. W. L. Brown, president of the American Ship Building Co., before the Merchant Marine Commission hearings in Chicago was especially illuminating. In referring



MR. W. L. BROWN.

to the great additions which have been made to the freight tonnage of the lakes during the past five years he stated that the total outlay in the ship building industry of the lakes would approximate $125,000,000. Of this enormous amount of ship construction the American Ship Building Co. has turned out in the neighborhood of 90 per cent. New work just at present, however, is very slack, but Mr. Brown believes only temporarily so. He holds that the era of big steel ship construction and car ferry construction for lake service has only begun. Lake trade has reached the point where the small vessel represented by the wooden carrier cannot be operated at a profit. Steel ships of greater capacity must be built to supplant them, and Mr. Brown expects at the close of the presidential campaign to see a number of large projects carried out which would involve the replacement of old tonnage by more modern bottoms. He also gave some most valuable data concerning the economy with which the modern carrier handles bulk freight on the lakes in conjunction with the improved facilities on the shipping and receiving docks. He attributed the excellent state of the industry on the great lakes to the protection afforded to it by the general government through the coastwise laws. In fact, Mr. Brown's testimony went to show that the ship building industry of the great lakes is a thoroughly sound and excellent business and that it is bound to continue so for a great many years.

LAKE SUPERIOR IRON MINES.

Duluth, July 6.—It is now estimated by officials of the roads that the two United States Steel Corporation railroads in the lake region, the Duluth, Missabe & Northern and the Duluth & Iron Range, will move about 1,000,000 tons under last year, when their combined shipment was not far from 11,000,000 gross tons. It was feared a few weeks ago that they would fall 20 per cent short. They are now shipping at a rate better than even 10 per cent under the season of 1903. Great Northern's season work may decline a trifle more proportionately.

Volunteer mine, near Negaunee, is to resume at once, both in mining and shipping the 200,000-ton stock of ore that accumulated last year and before. This is good news for that region for the Volunteer is looked upon as an important property. More than 200 men will be employed. In the same vicinity Richmond mine, a silicious lean bessemer property, mined open pit, has resumed and will operate all summer. It will make a large product for the season. It is possible that other mines of the same character will be busy this season. Three steam shovels are working at Negaunee; one each at Hartford, Regent and Cambria. Five shovels are loading from stock pile at the neighboring city of Ishpeming.

At Eveleth mines of the Oliver Iron Mining Co. they are hoisting day and night from Adams shafts Nos. 2, 4 and 5, and Spruce No. 2; and single shift from Adams No. 6 and Spruce No. 1. Shovels working one shift are loading from Adams stock piles at No. 2 and 5, and Spruce No. 2. Two Oliver company shovels are working double shift stripping at this mine. At Fayal, of this group, there is a shovel loading at stock pile No. 1 day and night, and another is loading cars from the open pit in No. 3 pit, also day and night. No. 2 pit is not yet active. The three shafts are all actively loading ore, day and night. Four shovels of the Drake & Stratton Co. are stripping day and night in the new pit. So that at these two large mines of the Oliver company at Eveleth there are steadily at work, most of them day and night, eleven large steam shovel and nine shafts. The Duluth & Iron Range road, which handles ore from Fayal mine, is running ten ore trains out of the place, and the Duluth, Missabe & Northern about as many. Daily ore shipments from the town are not less than 25,000 gross tons, and 2,500 men are at work in the mines at mining ore and stripping surface.

OBITUARY.

C. E. McArthur, author of Navigation Simplified, died recently at Daphney, Ala., of heart disease. He had been ill for over five years.

Capt. Sam A. Toms, a well-known riverman of the lower Mississippi, died June 29, at St. Louis, Mo. He had been with the St. Louis and Mississippi Valley Barge Co. since it was formed.

Capt. Geo. W. Robinson, of East Patchogue, L. I., died June 18. He was for thirty years engaged in the coasting trade. During the civil war, Capt. Robinson's schooner, the Marguerite W. Davis, was destroyed by the famous Florida. Capt. Robinson used to run a packet line between Boston, Charleston and Wilmington.

The Sahara, the second largest boat on the great lakes, took a cargo of 8,608 tons of soft coal from Lorain on her maiden trip. This is next to the Wolvin's record breaking cargo.

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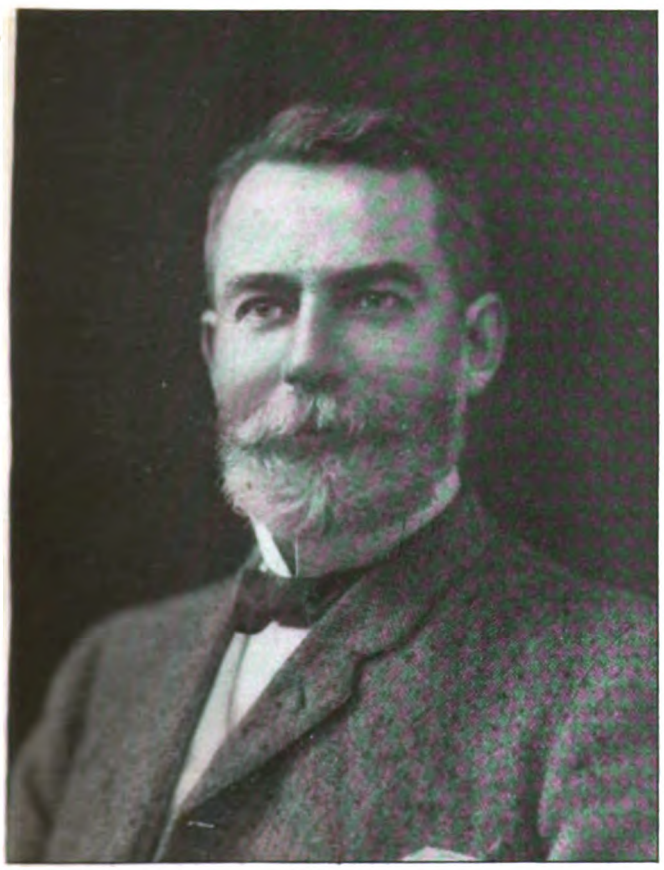
DEEP WATERWAY TO THE SEA.

Mr Antonio C. Pessano, president of the Great Lakes Engineering Works, Detroit, brought out a point of much importance at the Merchant Marine Commission hearings in Detroit recently and of which more is likely to be heard in the near future. He suggested that the national government take up the work which the state of New York has begun and complete a 25-ft. waterway to the sea along the route of the present Erie canal. Senator Gallinger was much interested in the suggestion and asked a number of questions concerning it. Incidental to it a point of great interest was made by Mr. George Y. Wisner who has been for the past three years the consulting engineer of the Montreal & Georgian Bay Canal Co. Mr. Wisner stated that a construction company was actually being formed to build a canal from Georgian Bay to Montreal, utilizing natural waterways most of the way. Mr. Wisner was of opinion that trade would naturally gravitate



MR. ANTONIO C. PESSANO.

along the deeper waterway and that a 12-ft. waterway in American territory would not be able to hold it. Mr. Pessano's contention was that with a deep waterway to the coast the manufacturers of the United States can change the industrial map of the world. He pointed out specifically the advantages to be derived by sending lake ships laden to all ports of the world. With a moderate differential duty there could be no question of the ultimate success of the enterprise. Moreover a deep waterway to the sea would have the effect of cementing the entire country, since the entire merchant fleet of the lakes could be put to government service as transports, should ever require. Mr. Pessano referred to the great difficulties which President McKinley had in 1897 of obtaining an adequate number of ships as government transports.

Mr. Pessano, while in the east during the past week saw Mr. Edwin S. Cramp of Cramp's ship yard and found him to be strongly of the opinion that a deep waterway from the lakes to the ocean would be of the utmost benefit to the country. He laid great stress upon the advantages of a waterway which would permit vessels of ocean draught to reach the great inland cities. Mr. Pessano is of opinion that a concertd effort should be made to enlist the attention of the national government to this project.

AROUND THE GREAT LAKES.

The new steamer F. W. Gilchrist has been docked at Lorain for repairs on account of injuries received while being launched at West Bay City.

The schooner Three Brothers was so badly squeezed between two other vessels at the St. Clair Rapids on June 24, that she has gone into dry dock.

The steamer Mariposa stranded 12 miles west of Whitefish point on June 24. The captain mistook the fog signal at Crisp's for the signal at Whitefish point.

The plant of the Erie Basin Ship Building Co., Buffalo, N. Y., has been sold to H. B. Root for $2,250. Mr. Root has not yet decided upon his plan for the operation of the dock.

The Anchor Line steamer Tionesta which went ashore 3 miles above White Fish Point, Lake Superior, during the heavy fog last week released itself without damage and proceeded on her trip.

V. Swain and John M. Nichol, two wood ships, the latter a package freighter, are the only vessels that laid up at Duluth-Superior not in commission. Both are liable to be idle all summer.

It is the opinion of marine men that the wreckage discovered two miles south of Gross Point by Capt. William Smith of the tug Perfection, is that of the schooner Wells Burt, which went to the bottom in 1882.

All salvage from tug Niagara, wrecked at Knife Island, Lake Superior, has been taken to Duluth by Whitney Bros., salvors. This includes engines, boilers and all iron and steel work of importance. It may be put into a new hull.

The Craig Ship Building Co., Toledo, has received a contract from the Grand Trunk Railway system for a car ferry to operate from the port of Milwaukee. The ferry will be 360 ft. long and 56 ft. beam and will cost approximately $400,000.

The Wayne circuit court decided against the Teagan Transportation Co., the Wolverine Steamship Co. and the Michigan Steamship Co. in their mandamus proceedings to compel the board of assessors at Detroit to strike from the tax rolls the floating property of the companies. The companies were assessed for a total of $780,000.

Mr. George W. Clark has been promoted from purser of the steamer City of Cleveland to the head of the ticket offices of the lines. Mr. John Shrugrow, purser of the Eastern States will succeed Mr. Clark as purser of the City of Cleveland and George Wells, freight clerk of the City of Cleveland, has been made purser of the Eastern States.

Although in commission only forty-eight hours, the steamer City of Benton Harbor was the scene of a strike June 27. As a result of an emergency order to remove water buckets, all the firemen, coal passers and oilers refused to honor the request and walked off the steamer. The steamer is now undergoing certain changes to retain guaranteed speed of 21 miles an hour. The water buckets are being removed and set in a different position inside the wheel. The strike will not delay operations of the steamer.

Last Saturday week the steamer Joe Milton ran ashore on Papoose Island in Georgian Bay on account of a dense fog. The violent lurching of the vessel overturned a lamp and the Joe Milton was burned to the water's edge. The captain and crew of fourteen men effected their escape in the boats after vainly attempting to extinguish the flames. The Joe Milton, which was engaged in the coasting trade along Bruce Peninsula, was one of the largest steamers of the fleet of the Crawford Tug Co., Wiarton; she was in command of Capt. Wm. Ferguson.

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THE WESTINGHOUSE-PARSONS TURBINE.

All turbines operate upon the broad principle of the kinetic energy of velocity of moving steam abstracted by the vanes of a rotating bucket wheel placed in the path of the jets. The Parsons construction, however, differs from the various other types using steam as a simple impulse water wheel, in that it combines the action of an impulse turbine with that of a reaction turbine, thus bearing a much closer resemblance to the ordinary hydraulic reaction turbine; furthermore, the Parsons type employs the principle of multiple expansion for the reduction of steam velocities in contra-distinction to a single expansion, as in the simple impulse turbine. This may be perceived from Fig. 1, which shows the general construction of a Westinghouse-Parsons steam turbine.

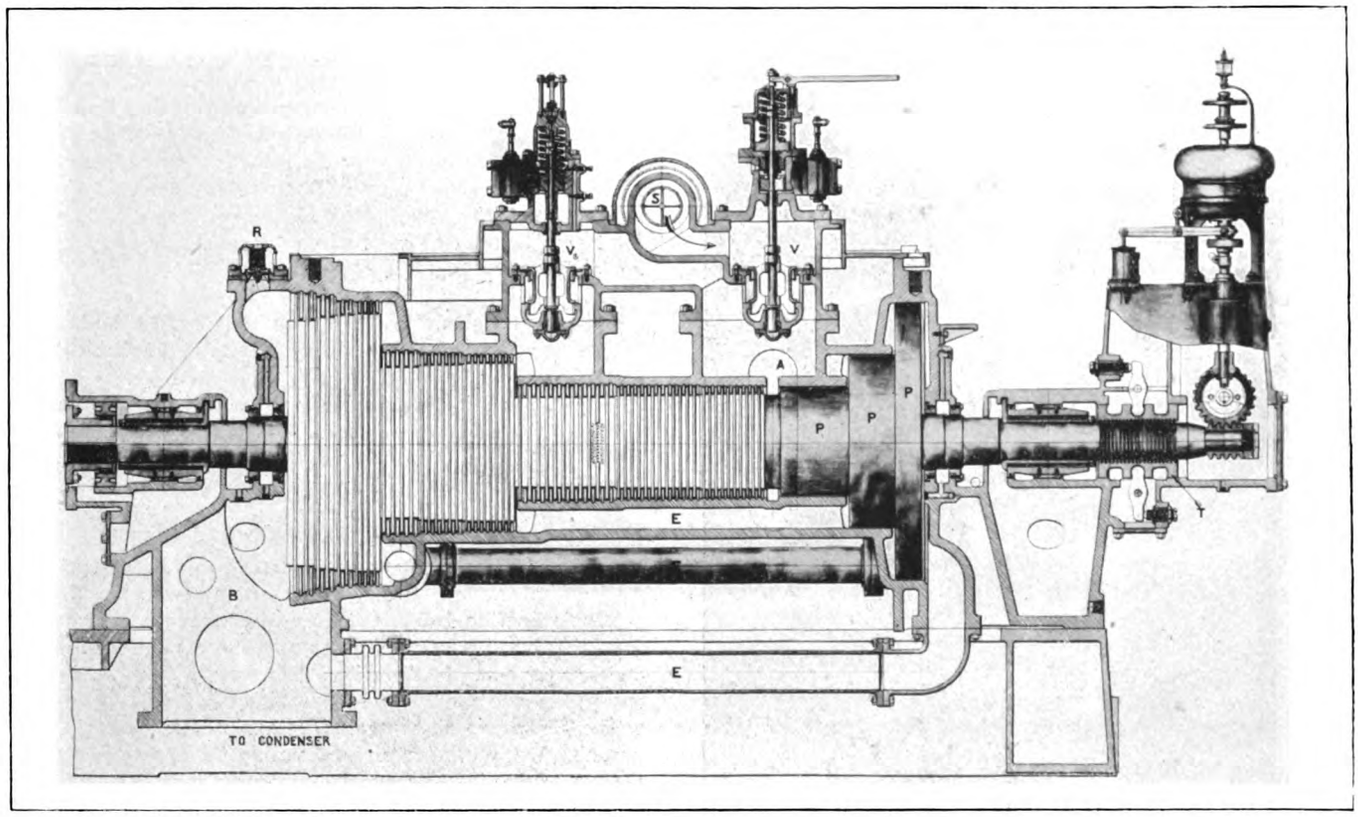

FIG. 1. SECTIONAL VIEW OF WESTINGHOUSE-PARSONS STEAM TURBINE.

Three essential elements may be observed; (1) the rotor; (2) the stator, and (3) the balancing pistons. The rotor consists of a cylinder of three or more drums of increasing diameter, upon the periphery of each of which are mounted numerous rings of radial vanes. The stator comprises a split casing of interior proportions conforming to those of the rotating cylinder. The interior walls of the casing are studded with rows of stationary radial blades corresponding to those on the moving cylinder but assembled with a reverse pitch.

High-pressure steam enters the turbine through the annular orifice A, expanding to the right through the several stages to the exhaust B. The rotating balance pistons, designated by the letter P, are equal in number to the number of drums, and each piston is of such diameter that the axial thrust resulting from the impact of the steam upon the blades of any drum is exactly balanced by corresponding pressure against the pistons. These pressures are at all times equalized by means of the ports and the pipes E, so that the balancing of the rotating element is entirely independent of the absolute or relative pressures in the various stages. The adjustment bearing, T, is therefore entirely relieved of axial thrusts. Its only function is to preserve the proper mechanical clearances between moving and stationary parts.

The balance pistons revolve within the casing with a close fit but without mechanical friction. Leakage of steam past the piston is prevented by deep grooves in the periphery which interposes so devious a path for the steam as to render loss from this source quite inappreciable.

In this form of turbine the area for the expansion of steam is secured by gradually increasing the annular volume between rotor and stator, which may be regarded as a single annular nozzle. Starting from A, blades of increasing length are employed in the first drum until a mechanical limit is reached, when the diameter is abruptly increased and a second progression begun with shorter blades, these again lengthening to the end of the second drum.

The form of blade used is the result of both theory and extensive experiment. They are usually made of a special bronze, cold drawn, of tensile strength averaging 75,000 to 80,000 lbs. per square inch, with 20 to 30 per cent elongation. This material is drawn out into long strips and the blades are then sawed off to the proper lengths. They are assembled by a calking process in grooves turned in the steam surfaces of rotor and stator. This method has proven so effective that the force required to pull out the blades exceeds the elastic limit of the material. It also greatly facilitates repairs, should such ever prove necessary. In comparison with the ultimate strength of the blades, the pressure exerted upon them from the impact of steam is minute, varying from .055 to .065 of a pound in a 400 kw. turbine, which is obviously but a small percentage of their bending sterngth. The very multiplicity of blades employed in this type therefore results in great inherent strength of construction.

Running clearances, both axial and radial, are ample to insure freedom of motion in all directions. Flexure or sagging of the shaft at the center is prevented by rigid quill construc-

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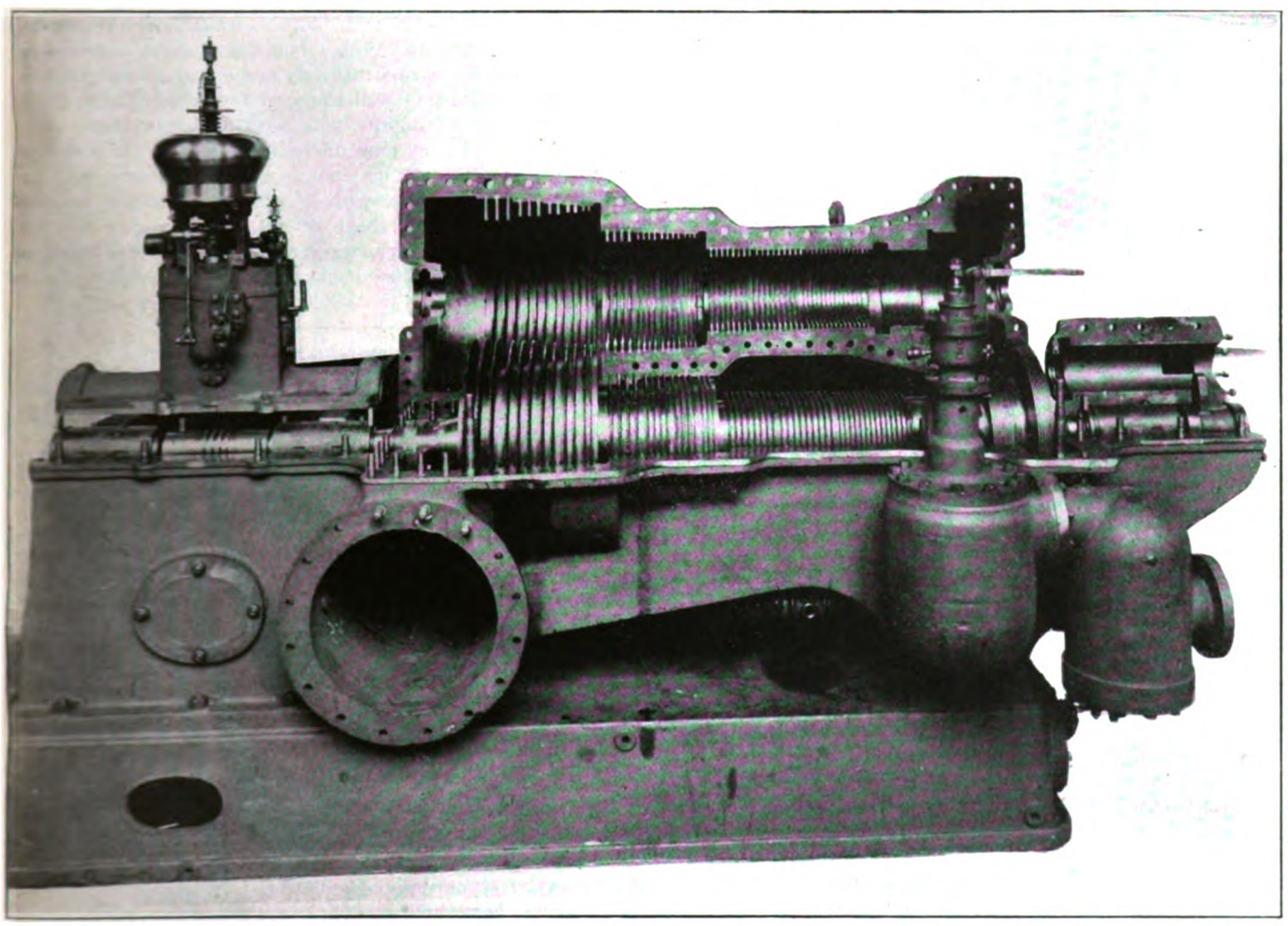
tion and the danger from adjacent rows of blades coming in contact is practically impossible on account of the large clearances employed, which vary from ⅛ in. to ¾ in. according to the size of the blades. These clearances are maintained by the adjustment blocks.

In the turbine approximately adiabatic expansion is realized, as no heat is taken in or given out, and the temperature of the casing remains approximately equal to that of the steam in each expansion stage. Both parts of the turbine are therefore approximately at the same temperature as that of the steam passing through the machine, and both expand and contract as a unit, thus preserving the original relation between moving and stationary blades. The stator, or casing, is anchored to the bed plate at the exhaust ends by heavy bolts, while the steam end rests upon a foot sliding between machined ways. The entire body of metal is thus free to move according to the temperature of the steam used.



400 KW. STEAM TURBINE OPENED FOR INSPECTION.

In order to facilitate inspection of the interior, the casing is split along a horizontal plane passing through the center of the shaft, and the upper half may be then lifted out by a crane, vertical guide rods preventing injury to the blades during this operation, as well as insuring the accurate registering of parts when again assembled. Each drum of the casing is designed to withstand a considerably greater pressure than would occur in practice, and is tested under this pressure at the shops to eliminate defects. A relief valve, R, at the top of the exhaust, B, prevents rupture of the casing in case of excessive back pressure.

Oil cushioned bearings are employed on all turbines running at speeds above 1,200 R. P. M. in order to provide sufficient flexibility to absorb vibrations occurring while the turbine is passing its critical speed; that is, changing from its geometric to its gravity axis. This construction consists of a nest of loosely fitting metallic sleeves surrounding the shaft and resting in a self-aligning seat in the pedestal. Oil circulates between the sleeves, and by capillary action, fluid cushions are formed which restrain vibration and at the same time give the desired flexibility. The shaft is therefore built as rigidly as is necessary to prevent flexure within the prescribed limits.

In turbines above 1,000 kw. capacity, the speeds are so low as not to necessitate the flexible bearing, so that a solid self-aligning bearing is used, split horizontally and adjusted by shims. The bearing surfaces are sufficient to carry the weight of the rotor on oil films without the use of forced lubrication. They are supplied by a small plunger pump driven by the turbine, which circulates oil through a closed system, comprising in the order of their arrangement; pump, oil cooler, bearings, and reservoir. The pressure of oil at the bearings never exceeds an equivalent static head of one to three feet.

The adjustment bearing, T, resembles a marine engine thrust bearing. It is built in two parts, set up in opposite directions by the levers and set screws shown. By means of graduations on the heads of the lower set screws, the axial clearances in the turbine may be determined within hundredths of an inch, and kept permanent.

Air and steam tight packing glands close the shaft openings in the casing so as to prevent the leakage of air into the exhaust, thereby impairing the vacuum. These glands are sealed by minute streams of pure water, which finally escape to the condenser.

No oil of any nature is used in the interior of the turbine.

Two steam admission valves are employed; a primary or main valve, V, and a secondary valve, Vs. Both are of the

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balanced, double beat poppet type, and removable, together with their bonnets, through openings in the steam chest. On all loads the primary valve, V, is in operation but the secondary valve, Vs, opens only when a predetermined degree of overload is reached. It then permits the entrance of steam to the second drum of the turbine in proportion to the overload, thus increasing the internal pressure and consequently the power. Each valve is operated by a small steam piston controlled by a relay valve, which in turn receives reciprocating motion from an eccentric driven from the worm shown at the end of shaft, which also drives the governor. High pressure steam is thus admitted to the turbine in short puffs with a constant frequency of about 150 strokes per minute.

The function of the governor is to vary the amplitude of this reciprocating motion as transmitted to the valve, thus in turn varying the period of steam admission to the turbine in proportion to the load. At full loads, the puffs of steam merge into nearly continuous blast, while at light loads, the steam is admitted only during brief periods. The ultimate objects of this method of governing are: (1) to utilize high pressure steam as far as possible at all loads; (2) to impress upon the governor mechanism a slight oscillatory motion sufficient to prevent the sticking of parts due to friction, thus improving the regulations.

The governor is of the centrifugal type with bell crank ball levers swung on knife edges, and resisted by a spiral spring, the pressure of which is adjusted by a knurled tension nut. This governor spring is mounted between ball bearings so that it may be brought to rest while the turbine is running. By increasing the spring tension, the speed of the turbine is increased, and vice versa. This affords a simple and effective means of synchronizing and alternating current generator for parallel operation, and for subsequently distributing the load between two or more A. C. generators operating in parallel.

Precautionary measures have been adopted in order to prevent the attainment by the turbine of excessive or destructive speeds. In machines of all sizes, the pilot valve controlling the main admission valve is so designed that an abnormal oscillation in either direction from mid-position will result in permanently closing the admission valve so that the turbine will come to rest, as in the case of a serious and prolonged short circuit, or the breaking of the governor mechanism. In addition a safety stop is frequently employed, especially in large sizes, which operates quite independently of the governor mechanism. It is usually mounted at the end of the turbine shaft and consists of a centrifugal governor which releases a trip valve at any predetermined speed. This valve in turn operates, through high pressure steam, an auxiliary quick closing throttle valve located in the main steam pipe. This safety stop may also be conveniently used in shutting down the turbine in emergencies, it being only necessary to trip the valve by hand.

REORGANIZATION PLAN OF THE FORE RIVER CO.

Kidder, Peabody & Co. of Boston have issued the official reorganization plan of the Fore River Ship & Engine Co. The new corporation is to have $1,250,000 paid in in cash and is to have $2,400,000 in 6 per cent non-cumulative preferred stock and $2,400,000 common stock. In a letter to the bond and stock holders, President Bowles says that for some time past it had been evident that the company's capital was insufficient for the conduct of its business, owing to the severe losses on contracts entered into by the old management, the quick capital had been entirely absorbed. The company had been compelled to borrow $600,000 on demand notes to meet daily outlays and complete the work in process. It became evident that these notes must be paid and new capital provided, and since the default on the bond interest April 1 the bond holders have assisted. During the last fifteen months in which the present board of directors has had charge of the company it has been necessary to make large expenditures to provide equipment, machinery, etc., and to build the railroad connections, which were imperatively necessary for the conduct of the work on hand. It was expected that ample money for these purposes had been provided by the bond issue, but the total sum of the expenditures has overrun the original estimates, to say nothing of the severe losses suffered during the past nine months and referred to above.

The works, with the additions to existing facilities which will be provided by the money raised by the present plan of reorganization, will be able to economically fulfill their present contracts, to cover the whole field of marine construction, and to take full advantage of their business which now amounts to about $4,000,000 a year. With the additions above referred to it may be confidently said that only one or two other yards in the country will be so well equipped for economically doing the highest class of ship building work, both naval and commercial. The plan as now offered is based on estimates as to the present value of the plant as a going concern, with the addition of $1,250,000 new cash, of which $600,000 will be used to discharge the notes above referred to. Besides this the present heavy interest charges on funded and floating debt will be removed, and the company's credit will be of the very best.

ITEMS OF GENERAL INTEREST.

The four-masted schooner Helen Taft was launched last week from the yard of Dunn & Elliott, Thomaston, Me. She is 197 ft. long, 41 ft. beam and 20 ft. deep.

Announcement from Vancouver, B. C., has been made that a new turbine steamer is to be built for the British Columbia-Australian service. She will be one of the fastest steamers on the Pacific.

The Alaska Steamship Co. is to have built at Tacoma another steamer larger than the Jefferson, recently launched, and to cost $100,000. After the new steamer is completed the company will build another sister ship, which will be launched Jan. 1, 1905.

A new gasoline speed yacht, supplemented with sails, has been completed at the ship yard of James T. Marsh, at Solomons, on the Patuxent river, Md. The engine installed is of the Globe type, 10 H. P., built by the Pennsylvania Iron Works. The craft was built for Edward C. Gardner of Washington, D. C. She is 30 ft. long, 10 ft. 6 in. beam and 3 ft. 6 in. depth.

Two large schooners were launched at Ballard, Wash., on June 15. The four-masted schooner, J. W. Clise, is the fifth of the fleet being built for the Globe Navigation Co. She is 250 ft. long, has a capacity of 1,100,000 ft. of lumber and cost $68,000. The schooner Columbia, belonging to the fleet of Albert Meyer & Co. of San Francisco was the other vessel launched.

The Smith & Mabley auto boat Vingt-Et-Un defeated the C. H. Tangeman boat Fiat in a race of 30 nautical miles on Long Island Sound last week by 20 min. 54 sec. and won the right to represent America in the race for the Harmsworth cup on the Solent, July. The average speed of the Vingt-Et-Un was 19.46 equal to 22.40 statute miles an hour. This speed with an engine of 75 H. P. is considered remarkable. The time made by the Standard with 125 H. P. on the Hudson was 20.53 nautical miles or 23.6 statute miles an hour.

The second meeting for the forming of the National Association of Engine & Boat Manufacturers was held last week at Hotel Manhattan, New York. An executive committee was elected which will meet on July 15 to elect officers. The association now has a membership representing fifty-four firms engaged in the manufacture of power boats and marine motors and other applications are pending. The association will at once establish offices in New York and the executive committee will take up the subjects needing attention.

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THE DE LAVAL STEAM TURBINE.

The De Laval steam turbine is a high speed rotary steam engine, in design and construction adapted for all purposes where the common reciprocating steam engine is now used, and for many other purposes where for various reasons no other type of engine meets hitherto impossible conditions. This is especially the case where great efficiency, great uniformity of rotation, and close regulation are important, as when used in connection with electrical machinery, centrifugal pumps, fans, blowers, etc. Its high speed and the directness of its energy conversion decreases the dimensions and weight, and simplifies the construction without impairing its efficiency, advantages which do not exist with the modern steam engine where great bulk and complexity are features indispensible to highly efficient operation. Its principal advantages are: No leakage from heat, no bearings to adjust, small friction loss, high efficiency with variable loads, no moving parts under pressure, close speed regulation, simplicity of construction, perfect balance, small foundations, small space occupied, ease of erection, automatic oiling, no danger from water, and long life.

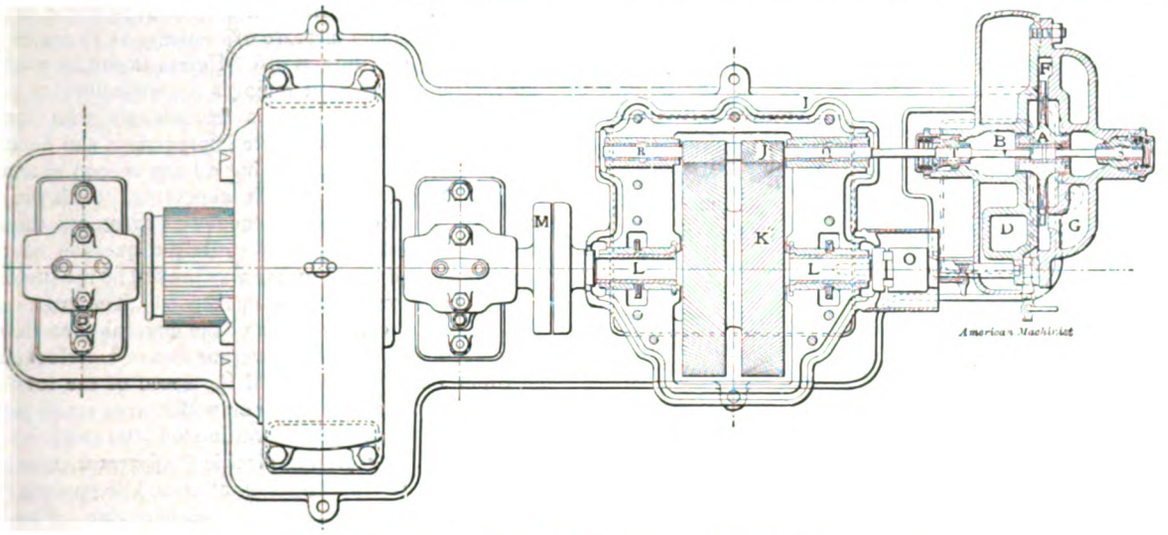

FIG. 1. SECTIONAL PLAN DE LAVAL TURBINE DYNAMO 30 H. P.

Unlike the reciprocating engine and other turbines the De Laval steam turbine has no stuffing boxes, no glands, no packing joints, and no working parts under pressure, which entirely eliminates the question of loss from leakage, in this respect differing from all other steam motors. The efficiency of a steam engine as given in a shop testing room may be of the very best, but after running, the leakage constantly increases and the efficiency decreases, while the turbine throughout its entire life remains absolutely constant in this respect, and a test made in the shops at the time a turbine is shipped would hold good for the same turbine after years of operation.

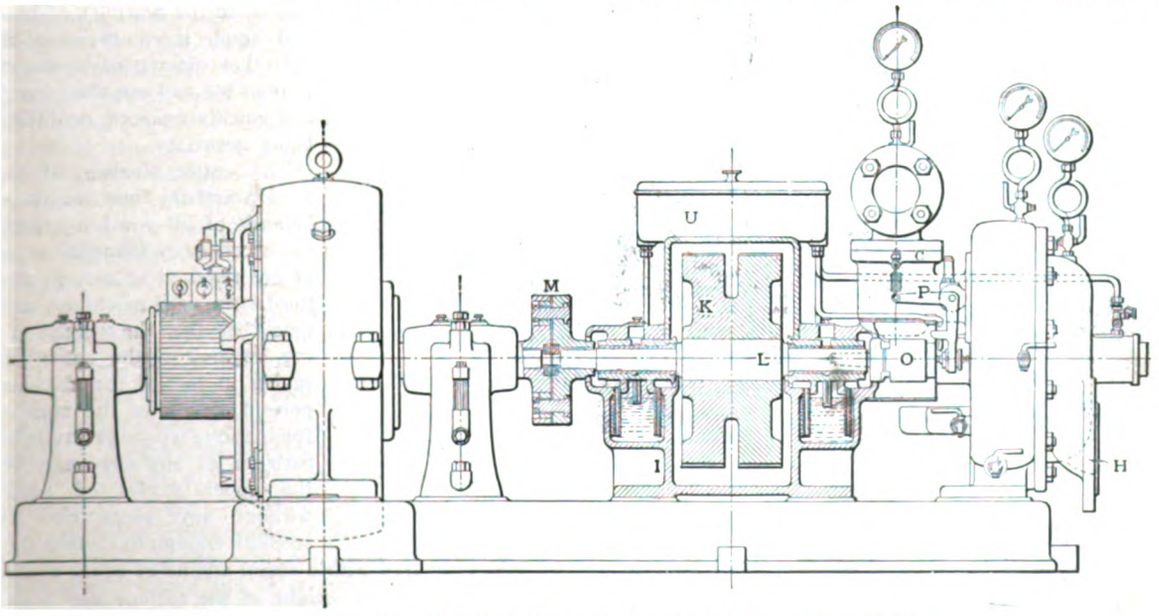

FIG. 2. SECTIONAL ELEVATION DE LAVAL TURBINE DYNAMO 30 H. P.

NO BEARINGS TO ADJUST.

As the motion of the turbine is entirely rotative, no adjustment of bearings whatever is necessary, and even should these become considerably worn, no bad effects will result. However, the pressure exerted on the various parts is so slight that the wear is surprisingly small, being much less, in every case, than with a steam engine used under the same conditions. Many De Laval turbines have been in constant operation in Europe for periods ranging from five to seven years without requiring the renewal or adjustment of a single bearing, and at the end of this time not showing any appreciable wear.

There is practically no friction loss to contend with in the

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turbine, while in the reciprocating engine the loss caused by poor or improperly adjusted packing and by piston or valve rods working out of parallel is often considerable, and a surprising difference in efficiency is often shown from these causes in a number of tests made with the same engine.

While the De Laval steam turbine running condensing will give a better efficiency than a compound condensing Corliss en-

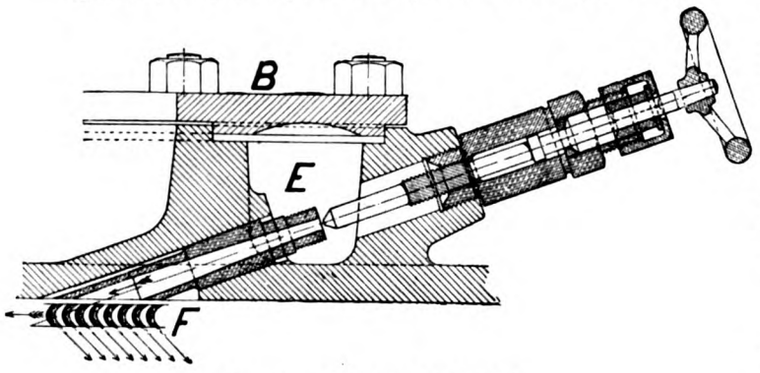
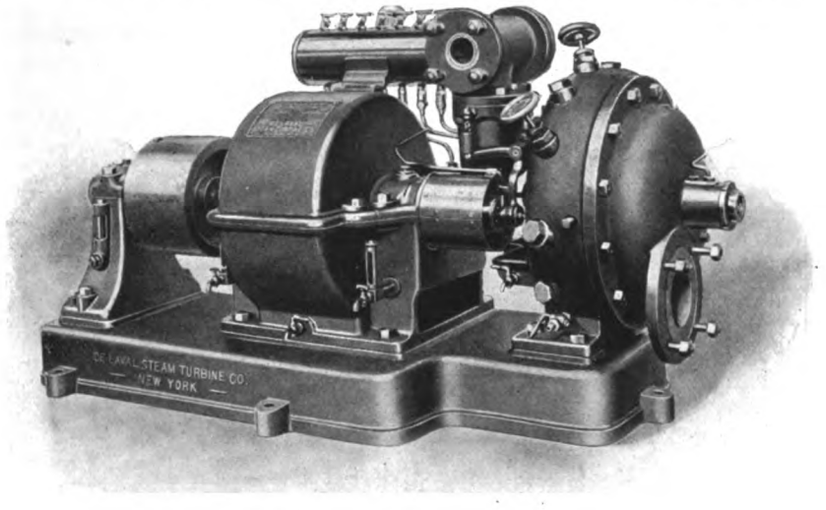


FIG. 3. DE LAVAL NOZZLE.

gine, there is the additional advantage in favor of the turbine that the efficiency of the reciprocating engine is given for its full rated load and the steam consumption per horse power largely increases with every increase or decrease of the load, while with the turbine the efficiency is practically the same from 25 per cent load to a 20 per cent over load. See diagram, page 12. It is undoubtedly a fact that in nearly every case a steam engine is running under-loaded rather than over-loaded throughout many of its working hours. This is particularly



DE LAVAL STEAM TURBINE MOTOR, 30 H. P.

so with an electric light plant, where the peak of the load lasts for a very short time, and during the balance of running time the engine must necessarily be operating at a great loss, in many cases more than doubling the quantity of steam used per horse power hour. In other words, the total amount of fuel required to operate a reciprocating engine at half-load is almost equal to the quantity required for a full-load, while with the turbine the steam consumption is nearly porportionate to the amount of work being performed. Fuel cost is beginning to assume an important aspect in this country, and this, coupled with the close competition in most lines of manufacture, necessitates taking advantage of every means of fuel-saving known. Nothing offers a better opportunity for thus economizing than the De Laval steam turbine. It is undoubtedly the excessive cost of fuel in Europe that has led to the general adoption of the steam turbine for all classes of power work so far in advance of its introduction into the United States. While as a general proposition Americans are in the lead in machine designing and construction, it is freely admitted that in steam engine practice Europeans lead the world.

NO MOVING PARTS UNDER PRESSURE.

As steam under pressure does not come in contact with any moving part in the turbine a very high pressure can be used with a considerable increase of economy as shown in diagram, page 11. This feature is also of great importance when using superheated steam, as it removes the difficulties of lubrication at high temperatures. It is undoubtedly with superheated steam that the greatest future improvement can be looked for in the reciprocating engine, but a limit is soon reached on account of the great difficulty in lubricating. With the De Laval steam turbine the saving is equally as great, but the allowable temperature and pressure is entirely a question of the steam boiler used and is not in any way limited by the turbine.

The speed regulation is unexcelled. The high speed, the simple and direct connection of the governing mechanism, and the exceedingly sensitive governor insure a perfect and, under all conditions safe control of the speed of the turbine, at the same time keeping the variation within very small limits. The value of this cannot be overestimated, especially where a machine is used for driving electrical apparatus, where the full load is often thrown off or on at once, a happening which has proven destructive to many a steam engine. The De Laval steam turbine is particularly adapted for operating alternating machines in parallel, as there is an entire absence of variation in angular velocity, which is responsible for so much trouble with reciprocating engines.

Simplicity of construction is one of the most important features of the De Laval steam turbine. The wearing parts are few, practically being limited to the bearings. These are plain and simple in construction, and like all the other moving parts are made interchangeable and can therefore be cheaply and quickly replaced, no fitting whatever being necessary.

The entire absence of reciprocating motion and the light weight and perfect balance of all revolving parts removes the necessity of foundations, except such as are required to sustain the weight of the larger sized machines, and as this is much less than the weight of reciprocating engines of the same capacity, the saving in cost of foundations is an important item. In the smaller sizes no foundations whatever are necessary, and turbines of any size may be placed in the upper stories of high buildings without any preparation other than strength enough to sustain the dead load.

As compared with a steam engine of equal power the space occupied and the weight of the turbine are both extremely small. A large part of the metal in a reciprocating engine is used to absorb the shock, which is entirely absent in the turbine, but a sufficient quantity of metal is used in the turbine wherever necessary to withstand any strains it may be called upon to resist, and a large factor of safety is allowed. The saving in space occupied, cost of building, transportation and erection, as well as weight and cost of repairs when needed, are items well worth consideration.

All turbine machinery is mounted upon a substantial bedplate, and owing to its light weight and small size is shipped completely assembled, and the erection easily and quickly made. In the construction of the De Laval steam turbine particular

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attention has been paid to the accessibility of all parts and the design is such as to make assembling or taking apart extremely simple.

The main shaft and dynamo bearings are ring oiling and require no attention other than an occasional refilling with oil. The bearings on the turbine shaft are fed from a common reservoir holding enough oil for a day's run, and a receptacle is provided in the base which collects all of the drip oil. This can be filtered and used over and over again. The oil reservoir is a closed one and can be connected with an elevated tank. By pumping the drip oil to tank after passing through a filter the system becomes automatic. The quantity of oil consumed under all conditions is much less than that used by a steam engine. Only one grade of oil is required for all parts of the turbine, and as this is of extremely light weight and low cost, the entire expense of lubrication is very slight, as the quantity of oil consumed under any conditions is much less than that used by a reciprocating engine.

There is absolutely no danger from water being carried over into the motor as there are no valves and no clearance spaces where damage could result therefrom, the only effect of a large body of water being a slight slowing down of the wheel until the water is disposed of. It is well, however, in all cases to use a separator close to the governor, as wet steam slightly increases the efficiency of the turbine.

An experience extending over a period of about eight years, during which time there have been placed on the market from the European factories upwards of four thousand steam turbines, has demonstrated that the wear in every case is very much less than any reciprocating engine. Some of these machines have been in operation during the entire time with practically no repairs, and at the most it has been only a matter of renewing some interchangeable babbitt bearings which can be removed or replaced without lifting the turbine wheel or the gear shaft from its position, and in an extremely short space of time. Unlike another well-known make of turbine there are no studs or pins about the governor or any other part of the De Laval turbine; these always give more or less trouble, and in the governors and valve motions of all types of reciprocating engines, where the centrifugal force makes them difficult to lubricate, they are soon worn flat on one side. In the turbine there is no valve motion to wear, as in the steam engine, or to cause excessive friction and consequent loss in efficiency, which is a considerable item even in the best so-called balanced valve engine. It is of course necessary that nothing but the very best of materials and workmanship should enter into the construction of the turbine and nothing has been left undone to make the De Laval steam turbine long-lived and free from accident.

DIRECT CONNECTED UNITS.

The De Laval steam turbine is particularly well adapted for direct connection to dynamos, centrifugal pumps, blowers, fire engines, etc. All such units are built and tested in the works, thus a decided advantage over the old method of buying the engine from one place, a generator or a pump from another, and having them fitted together on the ground where used, sometimes with great expense and delay and probably a poor piece of work as the result. All machines are ready when shipped from the car to be set down and operated wherever convenient, nothing being necessary but the connection of steam pipes, and switch-board connections in case of dynamos. The high speed, while objectionable in some classes of machinery, is certainly not in the turbine; the parts being so simple, perfectly balanced, and so well lubricated, are more reliable than those of even a slow moving reciprocating engine. The high speeds used in the De Laval steam turbine may seem extreme when applied to a steam engine, they are common in many other lines of work where the conditions imposed on the machine are more severe than with the turbine.

The De Laval Separator Company has during the last twenty years placed on the market over 250,000 centrifugal cream separators, which are running at speeds once considered absolutely out of the question. Moreover, these machines have been replaced in operation on farms and in creameries where they are handled by the cheapest class of help, and oftentimes with practically no attention and almost no repairs. In addition to these many thousands of other makes of separators have been sold and are in operation every day at speeds varying from 6,000 to 25,000 revolutions per minute. They are set up with poor foundations, or none at all, and frequently where care is not taken with the engine governor the speed even exceeds these figures. Aside from a rare accident, caused by the grossest carelessness, these machines are never heard of by the engineering public. If working under such conditions and at such speeds these separators give satisfaction, as they undoubtedly do, there should certainly be no question in the mind of a steam user as to the durability of the De Laval steam turbines, with their wonderful simplicity of construction and used as they are where all conditions are infinitely better, and where in the majority of cases they are in the hands of intelligent operators.

GENERAL DESCRIPTION OF THE TURBINE.

The general construction of the De Laval steam turbine will be clearly understood from the sectional plan and elevation (Figs. 1 and 2). The construction of the turbine it will be seen presents no extraordinary departure from every day engineering practice. However, the workmanship and material used, owing to the high speed employed, must be of the very highest quality. The wheel case and the wheel case cover are so shaped as to form "safety bearings' around the hub of the wheel for the purpose of catching and checking its speed in case of an accident to the shaft. The steam after passing through the governor valve C (Fig. 2) enters the steam chamber D, where it is distributed to the various nozzles. These, according to the size of machine, range in number from 1 to 15. They are generally fitted with shutting valves E (Fig. 3), by which one or more nozzles can be cut out when the turbine is not loaded to its full capacity. This allows steam of boiler pressure to be almost always used, and adds to the economy on light loads.

After passing through the nozzles, the steam, as elsewhere explained, is now completely expanded, and in blowing through the buckets F (Fig. 1), its kinetic energy is transfered to the turbine wheel. After performing its work the steam passes into the chamber G (Fig. 1), and out through the exhaust opening H (Fig. 2).

The velocity of the turbine wheel and shaft, in most cases too great for practical utilization direct, is considerably reduced by means of a pair of spiral gears, usually made 10 to 1. The gear is mounted and enclosed in the gear case I (Fig. 1). J is the pinion made solid with the flexible shaft and engaging the gear wheel K. This latter is forced upon the shaft L, which with couplings M, connects to the dynamo or is extended for pulley. O (Fig. 2) is the governor held with a taper-shank in the end of shaft L, and by means of the bell-crank P operates the governor valve C.

The flexible shaft is supported in three bearings (Fig. 1). Q and R are the pinion bearings and S is the main shaft bearing which carries the greater part of the weight of the wheel. This latter bearing is self-aligning and is held to its seat by the spring and cap shown. T is the flexible bearing. This bearing is entirely free to oscillate with the shaft, and its only purpose is to prevent escape of steam when running non-condensing, or air from entering the wheel case when the turbine is running condensing. All the bearings of the flexible shaft, as well as the gear wheel, are lubricated from a central

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oil reservoir U (Fig. 2), mounted upon the gear case; all other bearings are self-oiling. The bearings are plain and simple in construction, and made in two halves, so as to easily be taken out and examined. They are lined with the best quality anti-friction metal, are reamed true, round, and to exact size, and have the outside surface ground to insure perfect fitting and alignment. The bearings even in the largest sizes are removed and replaced without raising the shaft from its seat.

The gear wheels are made of solid cast steel, or of cast-iron with steel rims pressed on. The teeth in two rows are set at an angle of 90° to each other. This, while insuring smooth running, at the same time checks any tendency of the wheel and shaft to move lengthwise, thereby making a troublesome thrust bearing unnecessary. The gears are cut on automatic machines designed specially for this purpose, and a degree of accuracy has been attained not heretofore approached in gear wheel production. Owing to the high speed of the gears and their perfect alignment, the stress on the teeth is extremely small, and gears which have been examined after continuous operation for seven or eight years show no appreciable wear.

The flexible shaft is mainly supported on each side of the pinion by main bearings Q and R, the shaft is at the same time made very slender, which gives it a certain amount of flexibility and allows the turbine wheel, when the so-called critical speed is reached, to revolve around its true centre of gravity. This critical speed, dependent upon the flexibility of the shaft, occurs well below the normal speed of the turbine and marks the disappearance of all vibrations.

The turbine wheel is by far the most important part of the De Laval steam turbine and is in its present form the result of numerous experiments both as to shape and material. It is made of forged nickel-steel, and will withstand more than double the normal speed before showing any signs of distress. In smaller sizes the turbine wheels have a hole through the centre and are forced upon a taper sleeve shrunk on to the shaft. The larger wheels are made solid, with the shaft in two pieces screwed to the flanges of the wheel. The buckets are drop forged and made with a bulb shank fitted in slots milled in the rim of the wheel. By this method the buckets can easily be taken out and new ones inserted, should occasion require, without damage to the wheel.

TRADE NOTES.

The Atlantic Works, Inc., Philadelphia, Pa., recently shipped to the Oxford Ship Building Co., Oxford, Md., one of their bevel band sawing machines.

The August Mietz Foundry & Machine Works, New York, are building a 60 H. P. marine engine to be used in a southern houseboat. It will be shipped to its destination in a few days.

The Atlantic Works, Inc., Philadelphia, Pa., recently shipped to Wm. H. Reed, Portland, Me., one of their adjustable bevel band saw machines especially constructed for ship yard work.

In the ocean yacht race, from New York to Marblehead, given under the auspices of the Brooklyn Yacht Club, one of the principal prizes was on 8½-in. Chelsea striking ships' bell clock, manufactured by the Chelsea Clock Co., Boston, Mass.

Two little catalogues come from the Joseph Dixon Crucible Co., Jersey City, N. J. One is devoted to graphite cut greases and the other to Ticonderoga graphite grease. Both contain sensible information concerning these products and are to be had for the asking.

Dean Brothers, Indianapolis, Ind., in their pony catalogue No. 44 say that they have the largest and most complete line of steam pump patterns in America. The catalogue is a description of a few of them. For a small pocket catalogue it is very well gotten up. It is excellently printed upon enameled paper, and the half tone views of the various pumps show up well in it.

The B. F. Sturtevant Co. announce the removal of their entire plant from Jamaica Plains station to the new works at Hyde Park, Mass. With nine acres of floor space and all the modern appliances the company will continue to manufacture the well-known Sturtevant products—blowers, engines, motors, economizers, forges and steam heating, ventilating and drying apparatus.

The Grand Rapids Gas Engine & Yacht Co., Grand Rapids Mich., have just issued a catalogue devoted to their gas engines and yachts. They have built up a considerable trade in both and have received some most excellent testimonials from various users. They build speed launches to order and have been quite successful in making stern paddle wheel launches for use in shallow water.

"Graphite as a Lubricant" is the title of a very interesting catalogue just gotten out by the Joseph Dixon Crucible Co., Jersey City, N. J. It is maintained that graphite as a lubricant is in a class by itself. The catalogue is argumentive throughout and shows why lubrication can be much better obtained by the use of graphite. The catalogue is illustrated with some excellent photographs and is well worth preserving.

The Magnolia Metal Co. of New York has just issued a little decorated catalogue devoted to Magnolia metals. It is intended to be a book of useful information for engineers and mechanics. The book is illustrated with photographs of the officers of the company, photographs of the plant and with excellent wash drawings. It is crowded with information of value to the mechanic. The catalogue will be mailed to any one interested.

W. H. Armstrong and W. Kearns, formerly connected with the Chicago Pneumatic Tool Co., has formed a partnership under the name of Kearns & Armstrong, with offices in the Chamberlain building, Norfolk, Va. John F. Allen, New York, has just entered into an agreement with the new firm for the exclusive sale of the Allen riveters in Virginia, North and South Carolina, Florida, Georgia, Alabama and the District of Columbia.

The Fort Wayne Electric Works, Fort Wayne, Ind., have sent out a very pretty booklet under the general title "Summer Comforts." The booklet is devoted to the various uses to which fan motors may be put, and how much they really contribute to making the home and office comfortable during the hot weather. The booklet is gotten up in a very original manner. The illustrations, which have a photogravure effect, are on full pages, while the reading matter is on half-page insertions, permitting one to read the matter and at the same time to see the illustrations unobscured.

The New York Belting & Packing Co., Ltd., has moved to the spacious stores at Nos. 91-93 Chambers street and 73-75 Reade street, New York, between Broadway and Church streets. For some time past the company has felt the need of larger quarters in which to carry on their steadily increasing business, but until now have been unable to find a suitable and conveniently located building. In this connection the company has specially fitted up a room and equipped it with corresponding facilities, including telephone service, for the convenience of visitors. The company considers that it has the finest rubber store in the country.

The Holliday Mfg. & Engineering Co., 202 South Clinton street, Chicago, Ill., have recently received a number of orders from the Pacific coast for their engines and have made a shipment of clutches and propellers to Stockton, Cal. The company is now building a full line of reversible propellers and are making several new sizes of engines, which are not yet catalogued. They are also having a very nice trade in their reversible clutches. The reversing gears in the clutch are always in mesh, but never in use except when the propeller is reversed, consequently there is no liability of breaking as connection is made entirely by friction.

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SHIPPING LETTER FROM SCOTLAND.

Glasgow, June 16, 1904.—As the end of the first half of the year approaches symptoms of depression are reappearing in the ship building industry. During May the new contracts booked by Scotch shipbuilders represented about 55,500 tons, while the vessels launched aggregated 27,500 tons. A comparison of these figures suggests activity rather than depression, but there is little doubt that the recent impulse to order new shipping, in anticipation of improvement in freights before the tonnage is ready, has subsided. In the five months of the year the tonnage launched by Scotch builders aggregates 160,300 tons, as compared with 178,500 tons in the corresponding portion of last year. The new contracts booked during the same period will aggregate about 253,000 tons, but the contracts are very unevenly distributed among the builders, and include some exceptionally large liners. Last month's contracts include three P. & O. liners and two Elder-Dempster liners. The rush for big cargo tramps seems to have stopped for the present—happily for the owners of boats who already have difficulty in finding employment for them.

An interesting feature in our industry has been the production of a new turbine steamer for Australasia, viz.: the Loongana, built by William Denny & Bros., Dumbarton, for the Union Steamship Co. of New Zealand. Hitherto the turbine has been confined to river and cross-channel steamers, torpedo boat destroyers, and yachts, but the Loongana is intended for the inter-colonial trade for which she is especially designed. In appearance she is similar to the well-known Dumbarton steamers, but has the addition of a topgallant forecastle. She is constructed of steel, to scantlings approved by the British corporation registry in which she is classed. The first-class passengers, of whom the vessel carries about 240, will be accommodated amidships, and forward of the boilers, in staterooms which are fitted with all modern conveniences. The dining saloon is situated in a steel deckhouse on the upper deck. There is a large open vestibule on the upper deck where passengers embark, from which stairs lead down to the main deck accommodation and up to the vestibule and music-room on the deck above. The second-class accommodation, situated abaft the turbines, is somewhat similar to the first-class in comfort and convenience, differing only from it in the plainer finish of the various apartments. A feature has been made of the ventilating system, which consists both of natural draught ventilators and electrically-driven fans. The appliances for working the vessel at the terminal ports are very powerful, and consist of a windlass forward and warping winch aft. While the vessel is primarily intended for the passenger trade, she will carry a limited amount of cargo, for the rapid handling of which, together with the mails, she is provided with double derricks and a winch at each hatchway. She is being fitted with three sets of turbines by the Parsons Company, the boilers, etc., being supplied by Denny & Co.

At the usual launch Mr. James Denny made some interesting remarks. This was, he said, the thirty-fourth vessel his firm had built for the same company. The first order was given about thirty years ago. The vessel just launched was for the mail service between Australia and Tasmania and would have about a twenty-hours run, mostly in the open sea. For this service her speed would be constant and relatively great. She was thus specially suited for turbine machinery. This was in accordance with the practice of her owners to be well to the front. They were the owners of the first ocean-going steel steamer, and now they would be the owners of the first ocean-going turbine steamer for mercantile work. The fitting of turbine machinery was not without its penalties, as the recent experience in their appeal against the Board of Trade in connection with the Princess Maud has shown. That vessel created a publicity that was a surprise to them. Since the decision of the sheriff had been announced they had received from many unexpected quarters congratulations and expressions of thanks for the stand they had made. This showed how extensive the friction must be between the Board of Trade and those coming under its control. Such a state of affairs is not only deplorable but unnecessary. About eight years ago a committee to meet such cases was appointed, on the assurance of the then president of the Board of Trade (Mr. Ritchie), that such a committee would be welcomed by his board. This committee was nominated by the Institute of Naval Architects, the North East Coast Institute of Ship Builders and Engineers, and the Institute of Ship Builders and Engineers in Scotland—all scientific and not trade societies—and also one member nominated by the Belfast Chamber of Commerce. This committee might have done good work, but Mr. Ritchie was promoted and the present president of the Board of Trade (Mr. Gerald Balfour) gave the committee, in spite of the assurances of his predecessor, a very marked cold shoulder. The committee had a meeting with him a year or two ago and, while pointing out the welcome promised by his predecessor, asked that all proposed new regulations affecting ship and engine construction, that were to be issued thereafter by his department, should before issue be submitted to the committee, not for approval but simply that the board might have some idea of how such regulations would affect the manufacturers of ships and engines before they issued them and modify them or not accordingly. The committee made one other request, that in the event of their wishing to discuss any constructive details with the board, they could have meetings at request with the board's technical advisers, as a matter of right and not as a favor. The president had no hesitation in informing the committee that these requests, modest though they seem, could not be granted. No reason was given, except that Mr. Balfour "did not see his way." No doubt if they had been granted they might have been the means of putting some restraint on official and irresponsible action. Given a proper use of this committee by both sides disputes, such as that in which they were recently involved, would be impossible, and this committee was, therefore, entitled to loyal support from ship owners, ship builders, and engineers alike. It was the only existing bulwark between the manufacturers and official aggression, and it could not be ignored by the Board of Trade, as its former president gave it acknowledgment and the assurance of welcome. No one could doubt that the present position was most unsatisfactory.

A committee of the House of Commons is at present considering a proposal by the Clyde navigation trustees for the construction of further quays, wharves, river walls, etc., and the general improvement of the navigation of the river. Although the works proposed are comparatively small they are of great public importance. Since 1740 the improvements carried out on the Clyde have made Glasgow a port. At that date the nearest place to which even small ships could come was Port Glasgow, and anyone could wade across the Clyde at one of the bridges of Glasgow. Today the actual depth at Glasgow Bridge is from 20 to 22 ft. at low water, and 28 to 30 ft. at high water. The revenue of the port towards the end of the eighteenth century was £150. Last year it was £498,000. The improvement in the Clyde has been going on from year to year, and it is now necessary, if Glasgow is to hold its own, that ships drawing from 30 to 34 ft. of water should be able to go up and down the river. The trustees now propose to widen it from 500 to 600 feet. Glasgow also is the greatest ship building center in the United Kingdom. Large vessels of the Cunard services and warships are built there, and it is absolutely necessary to provide for their launching. To increase the width of the Clyde is of the utmost importance to the commercial prosperity of Glasgow. Sir John Ure Primrose, lord provost of Glasgow, and chairman of the Clyde trustees, as witness for the bill, examined, stated that the revenue of the Clyde trustees has increased from £4,600 a

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year about sixty years ago to £497,868 last year. He believes that in the current year which ends next month the revenue will be over half a million pounds. The works proposed in the bill are a necessary development of works already sanctioned. The Queen's dock is crowded out with shipping, and it is necessary to construct a new basin at Yorkhill. Trade has grown immensely and the Prince's dock is also filled up. The trustees have also to look after the increase of the size of vessels and give facilities for the increasing navigation. The welfare of the Clyde and the interest of the city of Glasgow depends upon the works proposed in the bill.

Large improvements are being made at Clydebank shipyard. John Brown & Co. have ordered from Cowan, Sheldon & Co., Carlisle, an electric jib derrick crane capable of lifting 150 tons. The new crane, which is to be erected alongside the firm's fitting out basin at the yard, is called for by the increasing size of the vessels now being built, and primarily by the firm having received the contract for one of the large turbine Cunarders, in the fitting out of which there will be a number of heavy lifts. The foundations of the crane will be built by Sir William Arrol & Co., Dalmarnock Iron Works, Glasgow. In connection with the building of the big Cunarder the company are also to increase the length of their fitting-out basin, its present length being insufficient to accommodate the vessel. Of the two sister intermediate Cunarders which the firm are building, the Caronia with reciprocating engines will be launched in July. The Carmania, which is to be fitted with turbines, is getting into frame. The experimental tank at the yard is now complete and some preliminary experiments have been made in it.

The trade between the Clyde and the St. Lawrence ports is now presenting a healthier appearance than the opening of the season promised. Heavier and more varied cargoes have been carried by the last vessels to arrive from Montreal and Quebec, and the belief is general that the worst of the season has been passed. Cattle shipments are a feature of this trade, the live stock being landed on alternate weeks at Liverpool and Glasgow. Pedigree stock is being freely sent out from this country in return.

A feature of marine insurance in the yachting season is the number of private pleasure craft which are being insured for the summer months. Although this country still possesses the largest fleet of steam yachts, America taking second place, many of the highest-valued vessels are owned by American capitalists. Mr. W. K. Vanderbilt, of New York, has renewed his insurance on the Valiant for £100,000, which was followed by one for £50,000 on the new steam yacht Warrior built for Mr. F. W. Vanderbilt. Two other steam yachts owned in America, valued at £100,000 each, are the Margarita, 1,797 tons, belonging to Mr. J. Drexel, registered in Philadelphia, and the Lysistrata, owned by Mr. J. Gordon Bennett, of Paris, the latter being of 2,089 tons, and registered in New York. An insurance has been effected at Lloyd's for £100,000 on a British steam yacht, the Lorena, built last year, and recently owned in New York by Mr. A. L. Barber. The Lorena now belongs to Mr. A. O. Depree of London. She is of 1,398 Thames tonnage, was built by Ramage & Ferguson at Leith, and was fitted with three steam turbines by the Parsons company. According to Lloyd's yacht register, the number of steam yachts owned in this country has increased since 1901 by an aggregate of nearly 13,000 tons, and the cost of construction averages £45 a ton. The insurances effected on pleasure yachts usually run only during the time they are in commission, which rarely exceeds four months.

The final report of the committee appointed by the admiralty to inquire into the whole questions of navy boilers will probably be presented this month. It is a long time since the committee was appointed, and their inquiries and tests have been most exhaustive, involving considerable sacrifices in time, etc., on the part of the members, but they have the satisfaction of knowing that even before their final report has been submitted their views have been given effect to in the service.

NORTH ATLANTIC RATE WAR.

Liverpool, June 20.—The North Atlantic rate war continues to be the all-absorbing theme for discussion in shipping circles here. Beyond the fact that the Cunard company have decided to lower their steerage rates to the United States, in order to place themselves on a level with the other Liverpool lines, there has been no new development this week, and at the time of writing there seems to be nothing to indicate that peace terms will be arranged in the immediate future. The Cunard company have not, however, dropped their steerage rates to the suicidal figure of $10, but are booking third class emigrants to New York or Boston at $15 by the Campania and Lucania, $13 by the Umbria, Etruria, Ivernia and Saxonia, and $12.50 by the Carpathia and Aurania. European emigrants are also being booked from Rotterdam, Hamburg, Bremen and Antwerp to New York or Boston at $15; Scandinavian prepaid rates, $18, and second-class rates from Paris by all ships to New York or Boston have been fixed at the same figure as from London. The first-class rates from London also apply to Paris, Hamburg, Bremen, Antwerp and Rotterdam bookings. The Cunard company, by adjusting their continental rates in the higher classes to the same level as those ruling from London, will deal a heavy blow at the German lines who initiated the fight, and this carrying the war into the enemy's camp will, it is hoped, be the means of a more compromising attitude on the part of the German lines being adopted. This, however, has not been made apparent as yet. In view of the large number of "undesirables" that are being attracted by the cheap steerage rates, most of the British lines are weeding out those applicants who are likely to be ineligible immigrants under the United States laws. The White Star line has just issued a special caution notice on this subject to all their agents, with advice how to act in doubtful cases, and an intimation that the amount of money which it is considered necessary the emigrant should possess on landing at New York is from $5 to $25, according to the distance he has to travel in addition to the inland railway fare or ticket. The managers of the lines interested in the Canadian trade, the Dominion, Allan, and the Canadian Pacific railway have met this week and determined that in view of the White Star charging a differential rate of $12 on boats such as the Cedric and Celtic to New York, all Liverpool lines to Quebec and Montreal should reduce their steerage rate to $12 commencing with next week's sailings from Liverpool. Since then, however, for what reason it is not stated, the before mentioned lines have arrived at a further decision to postpone the operation of their revised rates from Liverpool to Canadian ports until further notice. The rush to book passages at the $10 rate by the American line steamers sailing from Southampton for New York continues, and today the steamer Germanic, which is temporarily taking the place of the liner New York, while the latter is being repaired, will take out a full complement of steerage passengers. The emigrants who number about 850 belong mainly to the British agricultural class, there being a corresponding falling off in the foreigners this week. It is stated that the demand for berths has again been in excess of the accommodation.

New offices for the International Mercantile Marine company are about to be erected in London. The building at the west end of the block between Trafalgar Square and Pall-Mall is now being demolished, and on the site will be erected a building to accommodate the London staffs of the White Star, the American line, the Dominion line, and the Atlantic Transport line, together with the London agencies of the Red Star and the Hamburg-American lines.

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I have just learned that the Campania Transatlantica will on the 20th inst. inaugurate a new development of their passenger service in connection with their Royal mail steamers to the east. Hitherto the steamers of this line on their outward passage to the Philippines from Liverpool have proceeded direct from the principal Spanish ports. Following the lead of the other lines going through the Suez canal, the company have decided to take advantage of the overland route from England and the north of Europe, and tap the passenger traffic at Genoa. These steamers which are splendidly fitted for passenger service, having superior accommodation for first, second and third-class, will call regularly every 28 days at Genoa en route for Port Said, Colombo, Singapore and Manila. The call at Genoa on the homeward voyage will be commenced by the steamer leaving Manila on Aug. 2 and will be continued every four weeks afterwards. Stewards will be carried on these vessels who speak various languages, and the meals will be served a la carte if desired.

The new British cruiser, "Duke of Edinburgh," has been launched from the government dockyard at Pembroke this week. The vessel which is the 238th built at Pembroke dock, was named by the express command of King Edward to perpetuate to the British navy the memory of his late brother. She has water-tube and cylindrical boilers, and an estimated maximum speed of 22.23 knots. The Duke of Edinburgh, which will be one of the most powerfully armed cruisers in the British navy, will cost nearly approximately $5,050,000.

The British conference in favor of international codification of maritime law will be held in Amsterdam on Sept. 14, 15 and 16. This conference is in prosecution of the international conferences held in Brussels 1897, Antwerp 1898, London 1899, Paris 1900, and Hamburg 1902. The principal point on the agenda is the unification of maritime law as to the limitation of shipowners' liability. It is known that in this respect the British law widely differs from the American and Continental European law, it is said to the disadvantage at least a large class of British shipowners. The questions of jurisdiction in collision cases, mortgages, ownership, and rights in rem are also to be discussed at Amsterdam. The various national associations established in all mercantile centres of the world, will send representatives to that conference, as well as several ship owning and commerical associations. Of course Great Britain will be largely represented at the Amsterdam conference.

The announcement is made here that Messrs. M. P. Smith & Sons Co., engaged in stevedoring at New York in connection with the ship brokerage and commission merchant trades, have secured the contract for coaling the steamers of the Cunard line. This is a new departure for the Cunard company, as they have coaled their steamers on their own account since the line was started in 1840.

The Anchor line have now building a large twin screw steamer, to be named the "Caledonia," for their Atlantic trade. She will have accommodation for about 250 saloon, 375 second cabin, and 800 steerage passengers. She is to be launched in October next.

The New White Star steamer Baltic, the largest vessel in the world, which was launched by Messrs. Harland & Wolff at Belfast in November last, is expected to arrive in the Mersey at work from the builders. She is fixed to sail from Liverpool for the New York service on the 20th inst. I understand Capt. E. J. Smith, late of the Majestic, will be her commander.

Lord Lansdowne, British foreign secretary, made a very important statement in the House of Lords this week on the question of the coasting trade which may interest some of our readers at the present time. Replying to a question calling the attention of the British government to the practice of certain countries reserving what is termed their coastwise trade to vessels of their own nationality, and asking what had been the nature of the representations made to the United States government respecting the proposed application to the Philippine islands of the coastwise laws of the United States. Lord Lansdowne said there could be no doubt that the present system under which certain powers are allowed free access to British coastal trade was an unfair bargain and one which operated most distinctly against Great Britain. "Of course the extent of the injustice," Lord Lansdowne goes on to say, "is increased when we call to mind that when we speak of these reservators in coastal trade it does not mean the coasting trade, say, between one foreign port on the seaboard and another port on the same seaboard, but it can be more appropriately described as imperial trade—I mean trade, say, between the port of London and an Australian seaport; or taking the case of a foreign power, such trade as that which passes between New York and San Francisco, or from a Baltic port to Vladivostok. While I entirely realize the injustice to our commerce of this exclusion from a certain portion of the coasting trade of other powers, I think we must be careful not to exaggerate the extent of the grievance. It is not the case that that exclusion is by any means general or universal. Out of seven powers which do a large amount of coasting trade, four—Germany, Holland, Denmark and Portugal—admit our vessels free, and France does the same with the exception of the Algerian trade. There are only two powers therefore, Russia and the United States, which exclude us altogether. It is necessary, too, to bear in mind when we speak of possible retaliation, that these are the very powers which make the least use of our coasting trade, and so afford the smallest opportunity of replies of any kind. I am afraid, therefore, though I admit there is a grievance, that I cannot hold out any prospect of our immediately adopting the kind of steps which I understand it is wished for us to take. With regard to that part of the question referring to the Philippines, I have to say that in 1903 a bill was introduced in Congress under which the trade passing between the United States and the Philippine islands was declared to be coastwise trade of the kind that foreign vessels were denied participation in. That restriction seemed to us, on the face of it, inconsistent with certain declarations made by the United States government at the time when the treaty of peace was entered into between Spain and the United States, and it was therefore desired to call the attention of the United States government to the matter, and to point out the effect of these restrictions on the commerce of this country. These discussions are still proceeding, and I do not think it would be to the public interest that I should enter into details with regard to them. It is, however, a matter which deserves and will receive the attention of the government."

A Westinghouse Parsons turbine generating unit of 750-kw. capacity will be erected in the United States navy yard at Charleston, near Boston. The turbine will be of the new short-barreled type, and is now under construction at Pittsburg. A Worthington surface condenser will be employed, using salt water for circulation. A running vacuum of 28 ins. will be secured through the aid of a dry vacuum air pump. Steam will be furnished at 150 lbs. pressure by means of Babcock & Wilcox's boilers in units of 350 H. P. equipped with Roney mechanical stokers. The turbine plant will supply three-phase alternate current at 2,300 volts, and the turbine generator will be served by 37½ Westinghouse compound exciting unit.

The New York and Liberia Steamship Co., incorporated under the laws of New York, with a capital stock of $50,000, will begin operations with one steamship sailing from New York.

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APPOINTMENTS OF MASTERS AND ENGINEERS.

C. W. Kotcher, Detroit: Steamers—B. W. Blanchard, Capt. Wm. Crockett, Engineer, John Bloom; Saginaw, Capt. Wm. Hoffman, Engineer, A. Hayward; V. H. Pauly, Capt. A. H. Shafer, Engineer, H. Hisloh.

West Division Steamship Co., D. Sullivan & Co., Mgrs., Chicago: Steamers—Fred Pabst, Capt. D. C. Sullivan, Engineer, ———; W. H. Wolf, Capt. O. J. Loleau, Engineer, ———; Schooner Armenia, Capt. G. M. Dennis.

Lake Michigan and Lake Superior Trans. Co., Chicago: Steamers—Osceola, Capt. A. F Pitman, Engineer, Jas. Oag; Jay Gould, Capt. William D. Hardy, Engineer, Fred Larsen; City of Traverse, Capt. Joseph White, Engineer, Edward Meeh; Peerless, Capt. H. C. Page, Engineer, Henry Chalk.

A. B. Wolvin, Manager, Duluth, Minn., Provident Steam ship Co.: Steamers—James H. Hoyt, Capt. W. A. McLeod, Engineer, W. A. Moody; D. G. Kerr, Capt. E. D. Balentree, Engineer, Ed. Hunter; J. H. Reed, Capt. F. D. Houghton, Engineer, Jas. McPhee; D. M. Clemson, Capt. S. R. Chamberlain, Engineer, Jay Popp. Peavey Steamship Co.: Steamers—Frank H. Peavey, Capt. J. H. Johns, Engineer, Jas. Peterson; George W. Peavey, Capt. L. E. Boyce, Engineer, A. L. Roberts; F. T. Heffelfinger, Capt. John Tower, Engineer, Theo. A. Meyers; Frederick B. Wells, Capt. Alva A. Larer, Engineer, Geo. A. Gardner.

Wilson Transit Line, Cleveland: Steamers—Henry W. Oliver, Capt. W. W. Dawley, Engineer, Frank C. Stoeber; Captain Thomas Wilson, Capt. J. S. Wood, Engineer, Fred Harmon; Andrew Carnegie, Capt. J. McArthur, Engineer, Jas. F. Derrig; W. D. Rees, Capt. E. R. Morton, Engineer, Chas. V. Annable; Yuma, Capt. Daniel Buie, Engineer, John Heinkelmann; Spokane, Capt. Chas. A. Benham, Engineer, W. E. Donovan. The Volunteer Transit Co.: Steamer Charles Beatty, Capt. John Milne, Engineer, Gilbert McPhail.

David Vance & Co., Managers, Milwaukee, Wis. Inter-Ocean Navigation Co.: Steamers—Maryland, Capt. J. E. Yax, Engineer, M. Conley; Manchester, Capt. Tim Kelley, Engineer, Jas. Grant. Milwaukee Steamship Co.: Steamers—F. L. Vance, Capt. David L. Vail, Engineer, Emil Jahns; R. P. Flower, Capt. John J. Doyle, Engineer, Daniel Darcy. Wisconsin Steamship Co.: Steamer F. Schlesinger, Capt. F. W. Van Patten, Engineer, Richard Piepkorn.

W. C. Richardson, Cleveland: Steamers—W. C. Richardson, Capt. Thos. Wilford, Engineer, Jas. Falconer; Samuel Mitchell, Capt. John H. Babbitt, Engineer, A. C. Bowen; J. H. Wade, Capt. Philip H. Smith, Engineer, John McMonagle; J. H. Devereau, Capt. C. C. Mason, Engineer, Thos. Shannon; Romania, Capt. Wm. Hagan, Engineer, Oscar E. Flewelling; Iroquois, Capt. E. J. Burke, Engineer, Levi L. Bowen; J. H. Outhwaite, Capt. Ralph Nutting, Engineer, G. H. Miller; Iron King, Capt. James Ross, Engineer, Albert E. Bury; Wm. Edwards, Capt. Chas. Ahlstrom, Engineer, Moses Blondin. Schooners—Chickamauga, Capt. Harry W. Phillips; Crete, Capt. Henry Larsen; Mary B. Mitchell, Capt. John McKeighan; Iron Queen, Capt. D. A. Maynes; Golden Age, Capt. Daniel A. Stalker.

Union Steamboat Line, T. T. Morford, Mgr., Buffalo: Steamers—Starrucca, Capt. J. R. Gibson, Engineer, Alex A. Brown; Ramapo, Capt. Frank V. Hoehn, Engineer, H. Johnson; Tioga, Capt. Wm. McPherson, Engineer, Wm. Hayes; Binghampton, Capt. F. W. McQuilkin, Engineer, J. C. Tenant; Chemung, Capt. ———, Engineer, N. Johnson; Owego, Capt. ———, Engineer, R. Hill; Rochester, Capt. ———, Engineer, B. F. Goodwin; New York, Capt. ———, Engineer, J. Caul.

C. O. Jenkins, Manager, Cleveland: Mack Steamship Co: Steamers—Wm. H. Mack, Capt. John R. Preston, Engineer, Wm. H. Kennedy; F. B. Squire, Capt. A. J. Greenley, Engineer, H. L. Witter. Lake Erie Transportation Co.: Steamers—Wm. S. Mack, Capt. J. N. Comstock, Engineer, John Lowe; P. P. Pratt, Capt. Lehman, Engineer, Wallace Tomey. Schooner Athens, Capt. Geo. Mackie. Columbia Steamship Co.: Steamer Francis Widlar, Capt. Henry W. Stone, Engineer, J. F. Walsh.

U. S. Transportation Co., 1105 Williamson building, Cleveland: Steamers—L. C. Smith, Capt. Alex Forbes, Engineer, Robt. Leitch; Hurlbut W. Smith, Capt. J. H. Driscoll, Engineer, Wm. Roach; Wm. Nottingham, Capt. Sidney LeBeau, Engineer, John Courtney; Monroe C. Smith, Capt. C. D. Woodward, Engineer, H. J. Gregg; Geo. B. Leonard, Capt. Geo. W. Pierce, Engineer, Geo. Oldman; Wilbert L. Smith, Capt. H. L. Mills, Engineer, Jos. Taylor; B. Lyman Smith, Capt. Frank Boyer, Engineer, John Davidson; Chas. M. Warner, Capt. E. T. Rattray, Engineer, Geo. Milne; H. S. Wilkinson, Capt. A. M. Stalker, Engineer, Wm. Beekbissinger; W. W. Brown, Capt. J. H. Sinclair, Engineer, Harry Vaughn; W. W. Brower, Capt. F H. Reid, Engineer, Ed. Reading; William H. Gratwick, Capt. Jas. Riley, Engineer, Allen Landphere.

Cowle Transit Co., 1105 Williamson building, Cleveland: Steamer John B. Cowle, Capt. R. J. Lyons, Engineer, E. Hull.

Mona Transportation Co., 1105 Williamson building, Cleveland: Steamer Geo. Presley, Capt. D. R. Parsons, Engineer, John Cooper.

ITEMS OF GENERAL INTEREST.

S. M. Price of Smyrna, Del., will have a 50-ft. gasoline schooner built for freight purposes.

American, German and English capital is back of a new line of steamers for the coasting trade of Brazil.

An order for a new turbine steamer of 22½ knots has been placed by the Isle of Man Steam Packet Co., Messrs. Parsons supplying the machinery.

Fully $1,000,000 will be spent by the United States government in the establishment of a large coaling station at California City, San Francisco bay, on a tract of land acquired from Synde & Hough.

It is reported that a new type of battleship is to be introduced into the British navy. They are to be of low freeboard, and to have no high masts, funnels or cowls that would offer a mark to an enemy. They are to be heavily armed.

The twin-screw gasoline yacht Amalie has been sold to James H. Cassidy, through MacConnell & Cook of New York. She will be renamed the Ravenswood. The same firm has sold the schooner Wayward to Colonel David E. Austen.

John F. Cadigan bought at auction all the property of the Morse Iron Works & Dry Dock Co., South Brooklyn. The price was $50,000 over the mortgages, aggregating $510,000. The mortgagees will organize a new company and continue the business.

The new tug, Wissahickon, was launched recently by the Speddon Ship Building Co., Baltimore, for the United States revenue cutter service. Her dimensions are: 96½ ft. long over all, 88 ft. between perpendiculars, 20½ ft. beam and 10 ft. 3 in. depth of hold. Her displacement at mean draught is 175 tons.

The proposed Canadian-Mexican steamship line will have sailings both on the Atlantic and Pacific side. The ships in the Atlantic side will start from Montreal and call at Quebec, Halifax and St. John on the way down, and in the Pacific service opportunities will be given to all localities whence anything can be exported which is saleable in Mexico.

The Willamette Iron Works have received the contract to build a 90-ton steamer for the government, through Major Langfitt. Their bid for the steamer complete was $24,490. The vessel is to be of wood, 89.6 ft. long, 18 ft. beam, 9 ft. deep, and will have to be completed in 150 days after the date of the approval of the contract. The vessel will be built under government inspection, and on the trial trip the engines will be required to make 250 revolutions per minute.

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Length 106 ft., beam 22 ft.
Engine 10 by 20 by 11.
Boiler 8 ft. 6 in long, 48 in. dia.
Steam pressure 137 lbs.
Engine and boiler in first-class shape. Steam hoister and derrick forward.
Will sell cheap to quick buyer.
Address Walter V. Metcalf, 93 Eliot St, Cleveland. July 7

Dump Scow for Sale

Built of full length fir timber, 264 yards. For particulars enquire of Hickler Bros., Sault Ste. Marie, Mich. tf

Marine Boiler for Sale.

Scotch marine boiler 11 ft. diameter, 13 ft. ong; two furnaces; allowed 120 lbs steam. Practically new. Address Box 69, Marine Review, Cleveland. tf

FOR SALE.

Scow for Sale.

Large scow Koal Kabin, with one automatic Scotch four-drum deck hoist aft, one American two-drum deck hoist forward; with derricks and attachments for each hoist. One 6-in. ballast steam pump aft; one 9 in. windlass pump forward. New decks and beams. New Scotch boiler furnishes steam sufficient to operate pumps or hoists. Price $1,300. Come and look her over at Port Huron. R. P. Thompson, Port Huron, Mich. tf

For Sale.

All my stock in the Chequamegon Bay Transportation Co., 75 shares; good established business Reason for selling—going west. Address, Box 343, Ashland, Wis. July 28

WANTED.

Capstan Wanted.

Good second-hand steam capstan wanted. Give price and location. Address Box 68, Marine Review, Cleveland. July 21

PROPOSAL FOR CONSTRUCTION OF BREAKWATER.—U. S. Engineer Office, 262 Huron Street, Cleveland, Ohio, June 18, 1904. Sealed proposals for constructing the East Breakwater at Black River (Lorain) Harbor, Ohio, will be received at this office until 2 P. M., July 18th, 1904, and then publicly opened. Specifications, blank forms, and all available information will be furnished on application to this office. DAN C. KINGMAN, Major, Corps of Engineers, U. S. Army. July 14

U.S. Engineer Office, 1637 Indiana Ave., Chicago, Ill., June 25, 1904. Sealed proposals for dredging in Calumet River, Ill., will be received here until 12 noon, July 26, 1904, and then publicly opened. Information on application. O. H. ERNST, Col., Engineers. July 21

FOR SALE—The Union Transit Co.'s package freight steamer John M. Nichol. Rated A1½; length 263 ft., beam 41 ft., depth 26 ft. Triple expansion engines with 900 indicated H. P. Steel boiler house enclosing two Scotch boilers with steam pressure of 150 lbs. Steam capstans, windlass and steering apparatus. About $30,000 laid out for repairs in the past year. Retiring from business and will sell at sacrifice. Address H. C. French, 994 Ellicott Square, Buffalo, N. Y. June 16

FOR SALE—Steamer Plow Boy. 83 ft. long, 21 ft. beam, double compound engine. Allowed 269 passengers. Good established business at Houghton, Mich. Cheap for cash. Prefer to trade for Fishing Tug and Outfit. Dormer Boutin Fish Co., Bayfield, Wis. July 14

Steam Yacht Catherine.

FOR SALE—Length 78 ft., beam 18 ft., triple expansion engines, water tube boiler, allowed 200 lbs; electric light, search light, mahogany deck house 9 by 16, power launch, complete outfit, all in first-class condition. One of the best family cruising yachts on the Lakes Inquire Wickes Bros., Saginaw, Mich. July 7

FOR SALE—Steamer Isaac Lincoln, built 1898, rated A 1*. Carries 350 M ft. of lumber or 500 tons coal on 10½ ft. draught. Equipped with electric lights, steam steering gear, steam hoist, stockless anchors and is a good tower.

Also barge Robinson. Rated A 2. Carries 550 M ft. of lumber or 800 tons of coal on 11 ft. draught.

For further particulars address A. F. Price, Fremont, O. July 7

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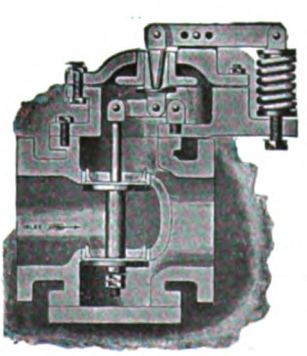

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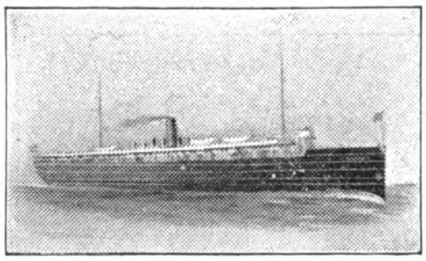

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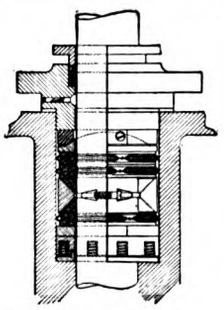

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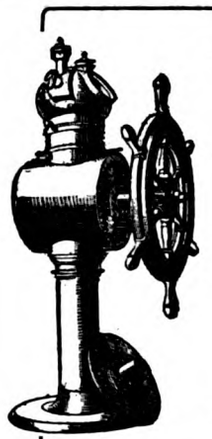

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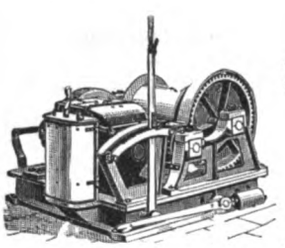

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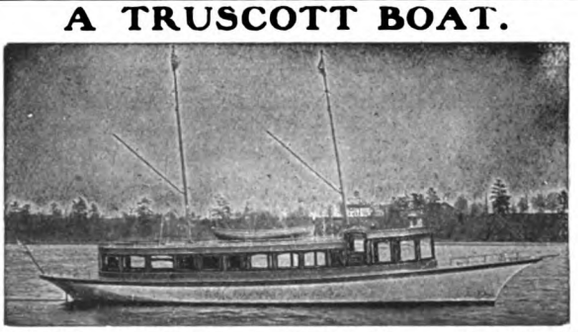

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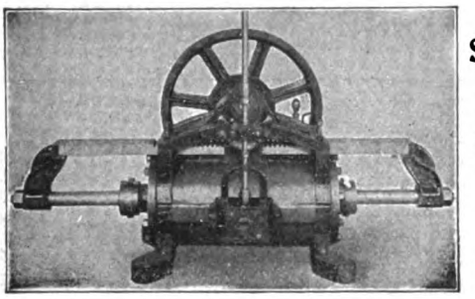

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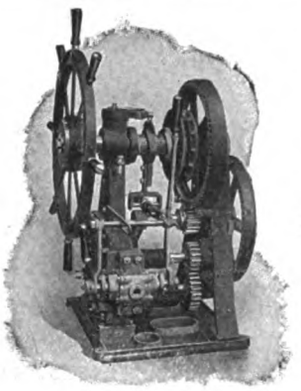

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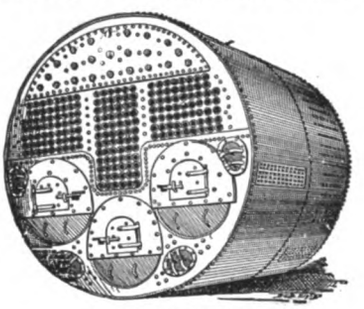

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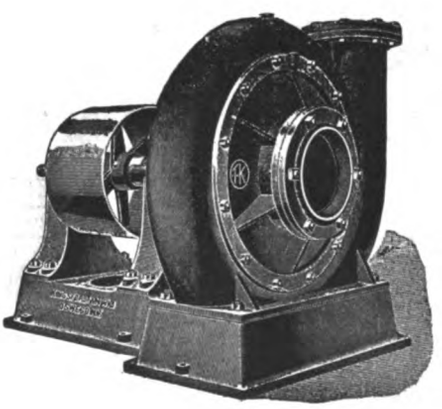

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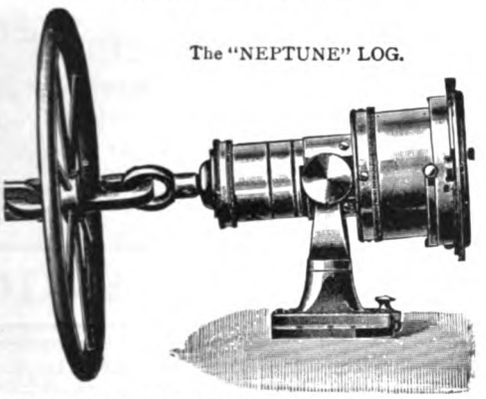

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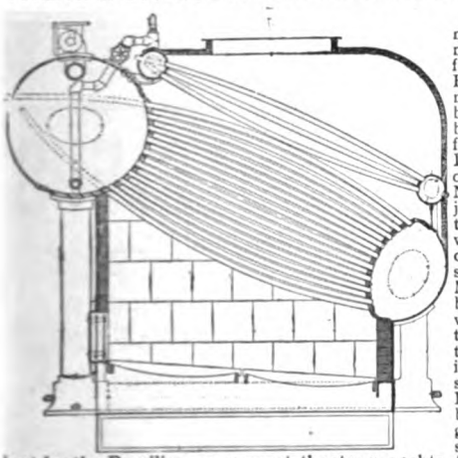

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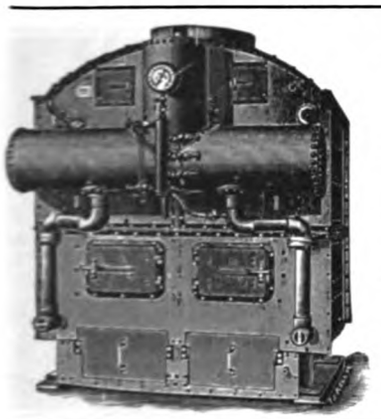

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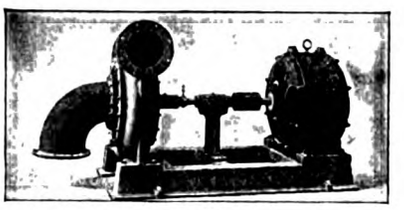

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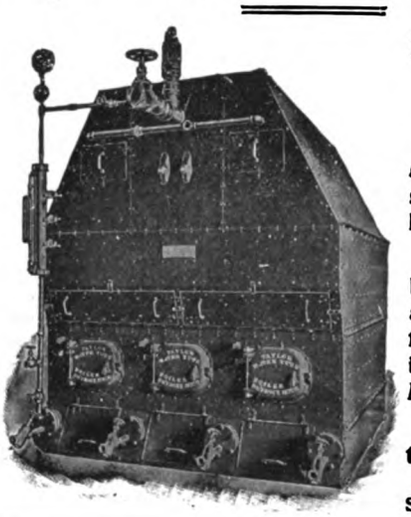

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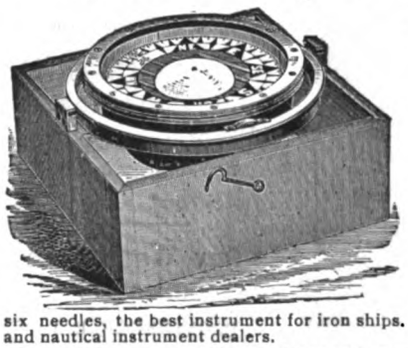

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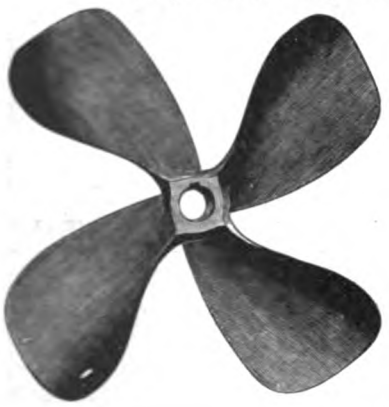

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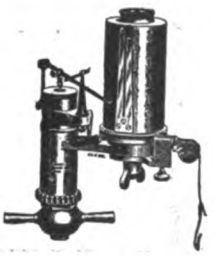

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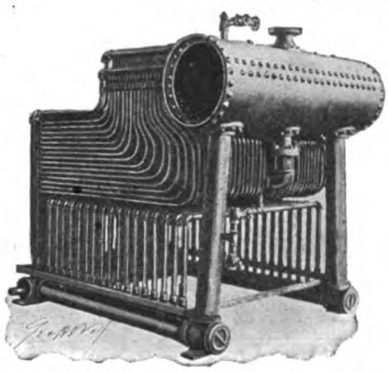

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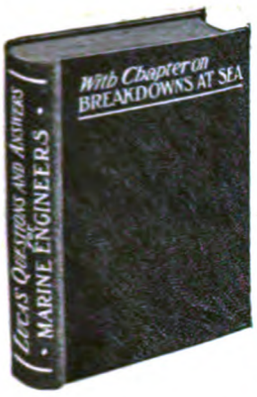

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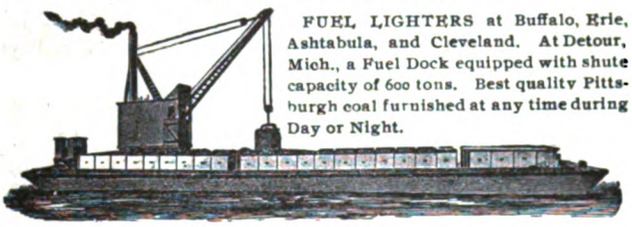

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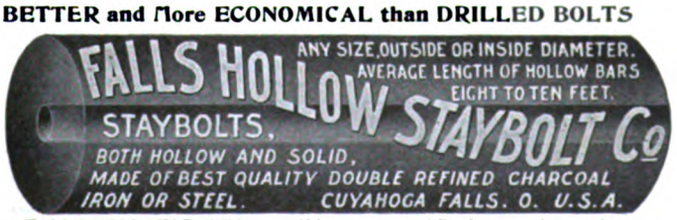
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Mosher Water Tube Boiler Co....New York.
Newport News Ship Building Co.....
.....Newport News, Va.
Northwestern Steam Boiler & Mfg. Co....
..... Duluth, Minn.
Roberts Safety Water Tube Boiler Co....
..... New York.
Stirling, The Co.....Chicago.
Superior Ship Building Co....Superior, Wis.
Taylor Water Tube Boiler Co.....Detroit.
Union Machine & Boiler Co.....Cleveland.
United States Ship Building Co....New York.
Willard, Chas. P. & Co.....Chicago.

BOILER COMPOUNDS.
Dearborn Drug & Chemical Works....Chicago.

BOILER RIVETS.
Bourne-Fuller Co.....Cleveland.

BOILER STAYBOLTS, IRON OR STEEL, HOLLOW OR SOLID.
Falls Hollow Staybolt Co..Cuyahoga Falls, O.

BOILER TUBES.
Bourne-Fuller Co. .....Cleveland.

BOOKS, NAUTICAL AND ENGINEERING.
Marine Review Pub. Co.....Cleveland.

BRASS AND BRONZE CASTINGS.
Cramp, Wm. & Sons.....Philadelphia.
Fore River Ship & Engine Co..Quincy, Mass.
Great Lakes Engineering Works.....Detroit.
Lunkenheimer Co. .....Cincinnati.
Macbeth Iron Co.....Cleveland.
Phosphor Bronze Smelting Co....Philadelphia.
Victor Metals Co.....Braintree, Mass.

BRIDGES, BUILDERS OF.
Scherzer Rolling Lift Bridge Co....Chicago.

BUCKETS, ORE AND COAL.
Brown Hoisting & Conveying Machine Co.
..... Cleveland.
Forest City Boiler Co. .....Cleveland.
Macbeth Iron Co. .....Cleveland.

CABIN AND CABINET FINISHING WOODS.
Martin-Barriss Co.....Cleveland.

CAPSTANS.
American Ship Windlass Co..Providence, R. I.
Hyde Windlass Co.....Bath, Me.
Marine Mfg. & Supply Co.....New York.

CEMENT, IRON FOR REPAIRING LEAKS.
Smooth-On Mfg. Co.....Jersey City, N. J.

CHAINS.
Lebanon Chain Works.....Lebanon, Pa.

CHAIN HOISTS.
Boston & Lockport Block Co....Boston, Mass.
Dake Engine Co.....Grand Haven, Mich.

CHARTS.
Marine Review Pub. Co.....Cleveland.
Potter, J. D.....London.

CLOCKS (Marine and Ship's Bell) AND CHRONOMETERS.
Ashton Valve Co.....Boston.
Ritchie, E. S. & Sons.....Brookline, Mass.
Standard Gauge Mfg. Co.....Syracuse, N. Y.

COAL PRODUCERS AND SHIPPERS.
Hanna, M. A. & Co.....Cleveland.
Pickands, Mather & Co.....Cleveland.
Pittsburg Coal Co.....Cleveland.

COAL AND ORE HANDLING MACHINERY.
Brown Hoisting Machinery Co. (Inc.) ..
..... Cleveland.
Lidgerwood Mfg. Co.....New York.
Macbeth Iron Co.....Cleveland.

COMPASS ADJUSTERS.
Fields, Capt. J. M.....Cleveland.

COMPASSES.
Ritchie, E. S. & Sons.....Brookline, Mass.

CONCRETE MIXERS.
Contractors Supply & Equipment Co..Chicago.

CONDENSORS.
Great Lakes Engineering Works.. Detroit.
Thropp & Sons Co., John E....Trenton, N. J.

CONTRACTORS SUPPLIES.
Contractors Supply & Equipment Co., Chicago.

CONTRACTORS FOR PUBLIC WORKS.
Buffalo Dredging Co.....Buffalo.
Chicago & Gt. Lakes Dredge & Dock Co.
..... Chicago.
Dunbar & Sullivan Dredging Co.....Buffalo.
Fitz-Simons & Connell Co.....Chicago.
Hickler Bros. .....Sault Ste. Marie, Mich.
Smith Co., L. P. & J. A.....Cleveland.
Starke Dredge & Dock Co., C. H..Milwaukee.
Sullivan, M. .....Detroit.

CORDAGE.
Baker & Co., H. H.....Buffalo.
DeGrauw, Aymar & Co.....New York.
Upson-Walton Co.....Cleveland.

CORK JACKETS AND RINGS.
Armstrong Cork Co.....Pittsburg, Pa.
Kahnweiler's Sons, D.....New York.

COURSE FINDER.
Field's Patent Course Finder.....Cleveland.

CHAIN CONVEYORS, HOISTS.
Brown Hoisting Machinery Co. (Inc.)....
..... Cleveland.
General Electric Co.....Schenectady, N. Y.
Lidgerwood Mfg. Co.....New York.
Westinghouse Electric & Mfg. Co.....
.....Pittsburg, Pa.

CRANES, TRAVELING.
Brown Hoisting Machinery Co.....Cleveland.
Lidgerwood Mfg. Co.....New York.
Pawling & Harnischfeger.....Milwaukee.

DIVING APPARATUS.
Morse, A. J. & Son.....Boston.
Schrader's Son, A.....New York.

DREDGING CONTRACTORS.
Buffalo Dredging Co.....Buffalo.
Chicago & Gt. Lakes Dredge & Dock Co..
..... Chicago.
Dunbar & Sullivan Dredging Co.....Buffalo.
Fitz-Simons & Connell Co.....Chicago.
Hickler Bros. .....Sault Ste. Marie, Mich.
Smith Co., L. P. & J. A.....Cleveland.
Starke Dredge & Dock Co., C. H...Milwaukee.
Sullivan, M. .....Detroit.

DRYING APPARATUS.
Bayley & Sons Co., Wm....Milwaukee, Wis.
Sturtevant, B. F., Co.....Hyde Park, Mass.

DRY DOCKS.
American Ship Building Co.....Cleveland.
Atlantic Works .....East Boston, Mass.
Buffalo Dry Dock Co.....Buffalo.
Chicago Ship Building Co.....Chicago.
Craig Ship Building Co.....Toledo, O.
Cramp, Wm. & Sons.....Philadelphia.
Detroit Ship Building Co.....Detroit.
Great Lakes Engineering Works.....Detroit.
Lockwood Mfg. Co.....East Boston, Mass.
Manitowoc Dry Dock Co.....Manitowoc, Wis.
Milwaukee Dry Dock Co.....Milwaukee.
Newport News Ship Building Co.....
.....Newport News, Va.
Shipowners Dry Dock Co.....Chicago.
Superior Ship Building Co....Superior, Wis.
United States Ship Building Co....New York.

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Buyers' Directory of the Marine Trade.—*Continued.*

ELECTRIC HOISTS AND CRANES.

General Electric Co.....Schenectady, N. Y.
Lidgerwood Mfg. Co.....New York.
Pawling & Harnischfeger.....Milwaukee.
Westinghouse Electric & Mfg. Co.....
..... Pittsburg, Pa.

ELECTRIC LIGHT AND POWER PLANTS.

Bayley & Sons Co.....Milwaukee, Wis.
General Electric Co.....Schenectady, N. Y.
Mietz, Aug.....New York.
Sturtevant, B. F. Co.....Hyde Park, Mass.
Trapp & Sons, John E.....Trenton, N. J.
Westinghouse Electric & Mfg. Co.....
..... Pittsburg, Pa.

ENGINE BUILDERS, MARINE.

American Ship Building Co.....Cleveland.
Atlantic Works .....East Boston, Mass.
Bertram Engine Works Co., Ltd. .....
..... Toronto, Can.
Chicago Ship Building Co.....Chicago.
Chase Machine Co.....Cleveland.
Cramp, Wm. & Sons.....Philadelphia.
Craig Ship Building Co.....Toledo, O.
Dake Engine Co.....Grand Haven, Mich.
Detroit Ship Building Co.....Detroit.
Hoboken W. & A. Co.....Hoboken, N. J.
Fore River Ship & Engine Co..Quincy, Mass.
Great Lakes Engineering Works Detroit, Mich.
Hall Bros. .....Philadelphia.
Jenks Ship Building Co....Port Huron, Mich.
Lawley's Mfg. Co.....East Boston, Mass.
Macbeth Iron Co.....Cleveland.
Mietz, Aug.....New York.
Milwaukee Dry Dock Co.....Milwaukee.
Morris, Chas. D.....New York.
Morton Steering Engine Co.....New York.
Newport News Ship Building Co.....
.....Newport News, Va.
Northwestern Steam Boiler & Mfg. Co....
.....Duluth, Minn.
Roach's Ship Yard .....Chester, Pa.
Seaverns Mfg. Co.....Milwaukee.
Superior Ship Building Co....Superior, Wis.
Trapp, J. E. & Sons Co.....Trenton, N. J.
Tuttle, H. G.....Buffalo.
United States Ship Building Co....New York.
Willard, Chas. P. & Co.....Chicago.

ENGINE ROOM TELEGRAPH, CALL BELLS, ETC.

Gray, Chas. & Son.....New York.
Marine Mfg. Supply Co.....New York.

ENGINEERING SPECIALTIES AND SUPPLIES.

Crane Co. .....Chicago.
Sykes & Mueller .....New York.
Lunkenheimer Co. .....Cincinnati.
Watts & Co., H. .....Milwaukee.
New York Belting & Packing Co..New York.
Northwestern Steam Boiler & Mfg. Co....
.....Duluth, Minn.

ENGINEERS, MARINE, MECHANICAL, CONSULTING.

Boyd, Alexander .....Cleveland.
Ewell, R. W. & Co.....Chicago.
Fitch, Joseph .....Duluth, Minn.
Gayley, H. O. .....Buffalo.
Wilson & Drake .....Philadelphia.
Morris, Chas. D.....New York.
Nolan, James .....Cleveland.
Pittsburg Testing Laboratory, Ltd...Pittsburg.
Pratt, Berry .....Buffalo.
Roelker, H. B.....New York.
Sickels, Jenkins & Field.....New York.
Smith, Adam .....Cleveland.
Wood, W. J. .....Chicago.

FANS FOR VENTILATION, EXHAUST, ETC.

Sturtevant, B. F. Co.....Hyde Park, Mass.

FEED WATER PURIFIERS AND HEATERS.

Dean Vance Co.....Troy, N. Y.

FIXTURES FOR LAMPS, OIL OR ELECTRIC.

General Electric Co.....Schenectady, N. Y.
Westinghouse Electric & Mfg. Co.....
.....Pittsburg, Pa.

FORGES.

Sturtevant, B. F. Co.....Boston.

FORGINGS FOR CRANK, PROPELLER OR THRUST SHAFTS, ETC.

Cleveland City Forge & Iron Co....Cleveland.
Fore River Ship & Engine Co..Quincy, Mass.
Macbeth Iron Co.....Cleveland.

FLUE WELDING.

Fix's, S. Sons .....Cleveland.

FURNACES FOR BOILERS.

Continental Iron Works.....New York.

FUELING COMPANIES AND COAL DEALERS.

Hanna, M. A. & Co.....Cleveland.
Ironville, Dock & Coal Co.....Toledo, O.
Parker Bros. Co., Ltd.....Detroit.
Picklands, Mather & Co.....Cleveland.
Pittsburg Coal Co.....Cleveland.
Smith, Stanley B., & Co.....Detroit,
Smith Coal & Dock Co., Stanley B.Toledo, O.

GASKETS, RUBBER.

New York Belting & Packing Co..New York.

GAS BUOYS.

Safety Car Heating & Lighting Co..New York.

GAS AND GASOLINE ENGINES.

Chase Machine Co.....Cleveland.
Georgian Bay Engineering Works.....
..... Midland, Ont.
Reliance Mfg. Co..... City Island, New York.

GAUGES, STEAM AND VACUUM.

American Steam Gauge & Valve Mfg. Co.
..... Boston.
Ashton Valve Co.....Boston.
Lunkenheimer Co. .....Cincinnati.
Standard Gauge Mfg. Co.....Syracuse, N. Y.

GAUGES, WATER.

Bonner & Co., Wm. T.....Boston.
Lunkenheimer Co. .....Cincinnati, O.
Standard Gauge Mfg. Co.....Syracuse, N. Y.

GRAPHITE.

Dixon Crucible Co., Joseph..Jersey City, N. J.

HAMMERS, STEAM.

Chase Machine Co.....Cleveland.

HEATING APPARATUS.

Bayley & Sons Co., Wm.....Milwaukee, Wis.
Sturtevant, B. F. Co.....Hyde Park, Mass.

HOISTS FOR CARGO, ETC.

American Ship Building Co.....Cleveland.
Brown Hoisting Machinery Co. (Inc.)....
..... Cleveland.
Chase Machine Co.....Cleveland.
Elwell-Parker Electric Co.....Cleveland.
General Electric Co.....New York.
Georgian Bay Engineering Works.....
..... Midland, Ont.
Hyde Windlass Co.....Bath, Me.
Lidgerwood Mfg. Co.....New York.
Marine Iron Co.....Bay City.
Mietz, Aug. .....New York.
Pawling & Harnischfeger .....Milwaukee.
Westinghouse Electric & Mfg. Co.....
.....Pittsburg, Pa.

HOLLOW STAYBOLT IRON.

Falls Hollow Staybolt Co...Cuyahoga Falls, O.

HOSE, RUBBER.

New York Belting & Packing Co..New York.

HYDRAULIC DREDGES.

Great Lakes Engineering Works.....Detroit.

HYDRAULIC TOOLS.

Watson-Stillman Co., The.....New York.

ICE MACHINERY.

Great Lakes Engineering Works.....Detroit.
Roelker, H. B.....New York.

INDICATORS FOR STEAM ENGINES.

American Steam Gauge Co.....Boston.
Ashton Valve Co.....Boston.

INJECTORS.

American Injector Co.....Detroit.
Crane Co. .....Chicago.
Jenkins Bros. .....New York.
Lunkenheimer Co. .....Cincinnati.
Penberthy Injector Co.....Detroit, Mich.

INSURANCE, MARINE.

Elphicke, C. W. & Co.....Chicago.
Fleming & Co., P. H.....Chicago.
Frankfort Marine, A. & P. G. Ins. Co....
..... New York.

INSURANCE, MARINE—Continued.

Gilchrist & Co., C. P.....Cleveland.
Hawgood & Co., W. A.....Cleveland.
Helm & Co., D. T.....Duluth.
Hutchinson & Co.....Cleveland.
McCarthy, T. R.....Montreal.
McCurdy, Geo. L.....Chicago.
Mitchell & Co.....Cleveland.
Parker Bros. Co., Ltd.....Detroit.
Peck, Chas. E. & W. F..New York & Chicago.
Prindiville & Co.....Chicago.
Richardson, W. C.....Cleveland.
Sullivan, D. & Co.....Chicago
Voss, F. D.....New York.
Weeks, F. H.....New York.

IRON ORE AND PIG IRON.

Bourne-Fuller Co.....Cleveland.
Hanna, M. A. & Co.....Cleveland.
Pickands, Mather & Co.....Cleveland.

LAUNCHES—STEAM, NAPHTHA, ELECTRIC.

Georgian Bay Engineering Works.....
..... Midland, Ont.
Marine Construction & D. D. Co.....
.....Mariner's Harbor, S. I., N. Y.
Truscott Boat Mfg. Co.....St. Joseph, Mich.
Willard, Chas. P.....Chicago.

LIFE PRESERVERS, LIFE BOATS, BUOYS.

Armstrong, Cork Co.....Pittsburg.
Drein, Thos. & Son.....Wilmington, Del.
Kahnweiler's Sons, D. .....New York

LIGHTS, SIDE AND SIGNAL.

Russell & Watson .....Buffalo.

LOGS.

Walker & Sons, Thomas ....Birmingham, Eng.
Also Ship Chandlers.

LUBRICATING GRAPHITE.

Dixon Crucible Co., Joseph..Jersey City, N. J.

LUBRICATORS.

Crane Co. .....Chicago.
Lunkenheimer Co. .....Cincinnati.

LUMBER.

Martin-Barriss Co.....Cleveland.

MACHINISTS.

Chase Machine Co.....Cleveland.
Gogebic Steam Boiler Works....Duluth, Minn.
Hickler Bros. .....Sault Ste. Marie, Mich.
Lockwood Mfg. Co.....East Boston, Mass.
Macbeth Iron Co.....Cleveland.
Union Machine & Boiler Co.....Cleveland.

MACHINE TOOLS (WOOD WORKING).

Atlantic Works, Inc.....Philadelphia.

MARINE RAILWAYS.

Hickler Bros. .....Sault Ste. Marie, Mich.

MARINE GLUE.

Ferdinand & Co., L. W.....Boston, Mass.

MARINE RAILWAYS, BUILDERS OF.

Crandall & Son, H. I....East Boston, Mass.

MATTRESSES, CUSHIONS, BEDDING.

Fogg, M. W.....New York.

MECHANICAL DRAFT FOR BOILERS.

American Ship Building Co.....Cleveland.
Detroit Ship Building Co.....Detroit.
Great Lakes Engineering Works ..Detroit.
Sturtevant, B. F. Co.....Hyde Park, Mass.

MELTING POT AND PAYING LADLE.

(For Paying Seams of Decks with Marine Glue.)

Ferdinand & Co., L. W.....Boston.

METALLIC PACKING.

Katzenstein, L. & Co.....New York.
U. S. Metallic Packing Co.....Philadelphia.

METAL POLISH.

Bertram's Oil Polish Co.....Boston

MOTORS, GENERATORS—ELECTRIC.

General Electric Co.....Schenectady, N. Y.
Bayley & Sons Co., Wm.....Milwaukee, Wis.
Sturtevant, B. F. Co.....Hyde Park, Mass
Westinghouse Electric & Mfg. Co.....
..... Pittsburg, Pa.

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Buyers' Directory of the Marine Trade.—*Continued.*

NAUTICAL INSTRUMENTS.
Ritchie, E. S., & Sons.....Brookline, Mass.

NAVAL ARCHITECTS.
Hynd, Alexander .....Cleveland.
Kidd, Joseph.....Duluth, Minn.
Lovejoy, H. O.....Buffalo.
Matteson & Drake.....Philadelphia.
Mosher, Chas. D.....New York.
Nacey, James .....Cleveland.
Rice, Henry .....Buffalo.
Sadler, Perkins & Field.....New York.
Steel, Adam .....Cleveland.
Wood, W. J.....Chicago.

OAKUM.
DeGrauw, Aymar & Co.....New York.
Stratford, Oakum Co.....Jersey City, N. J.

OIL FOR PAINTING.
Sipe & Co., James B.....Allegheny, Pa.

OIL ENGINES.
Mietz, Aug. .....New York.

OILS AND LUBRICANTS.
Dixon Crucible Co., Joseph..Jersey City, N. J.
Standard Oil Co.....Cleveland.

PACKING.
Crane Co. .....Chicago.
Jenkins Bros. .....New York.
Katzenstein, L. & Co.....New York.
New York Belting & Packing Co...New York.
United States Metallic Packing Co.Philadelphia.

PACKING TOOL.
Matteson & Drake .....Philadelphia.

PAINTS.
Baker, Howard H. & Co.....Buffalo.
Detroit Varnish Co.....Detroit.
Detroit White Lead Works.....Detroit.
Forest City Paint and Varnish Co..Cleveland.
New Jersey Zinc Co.....New York.
Sipe & Co., James B.....Allegheny, Pa.
Upson-Walton Co. .....Cleveland.

PATTERN SHOP MACHINERY.
Atlantic Works, Inc.....Philadelphia.

PILE DRIVING AND SUBMARINE WORK.
Buffalo Dredging Co.....Buffalo.
Chicago & Gt. Lakes Dredge & Dock Co..
.....Chicago.
Dunbar & Sullivan Dredging Co.....Buffalo.
Fitz-Simons & Connell Co.....Chicago.
Hickler Bros. .....Sault Ste. Marie, Mich.
Parker Bros. Co., Ltd.....Detroit.
Smith Co., L. P. & J. A.....Cleveland.
Starke Dredge & Dock Co., C. H...Milwaukee.
Sullivan, M. .....Detroit.

PIPE, WROUGHT IRON.
Bourne-Fuller Co.....Cleveland.
Crane Co. .....Chicago.
Macbeth Iron Co.....Cleveland.

PLANING MILL MACHINERY.
Atlantic Works, Inc.....Philadelphia.

PLATES—SHIP, STRUCTURAL, ETC.
Bourne-Fuller Co. .....Cleveland.
Otis Steel Co.....Cleveland.

PNEUMATIC TOOLS.
Allen, John F.....New York.

POLISH FOR METALS.
Bertram's Oil Polish Co.....Boston.

PRESSURE REGULATORS.
Kieley & Mueller .....New York.
Ross Valve Co.....Troy, N. Y.

PROPELLER WHEELS.
American Ship Building Co.....Cleveland.
Atlantic Works .... East Boston, Mass.
Cramp, Wm. & Sons.....Philadelphia.
Detroit Ship Building Co.....Detroit.
Fore River Ship & Engine Co..Quincy, Mass.
Great Lakes Engineering Works.. Detroit.
Hyde Windlass Co.....Bath, Me.
Jenks Ship Building Co....Port Huron, Mich.
Lockwood Mfg. Co.....East Boston, Mass.
Macbeth Iron Co.....Cleveland.
Milwaukee Dry Dock Co.....Milwaukee.
Newport News Ship Building Co.....
.....Newport News, Va.
Phosphor Bronze Smelting Co., Ltd.....
.....Philadelphia.
Roelker, H. B.....New York.
Sheriffs Mfg. Co.....Milwaukee.
Superior Ship Building Co....Superior, Wis.
Thropp & Sons Co., J. E.....Trenton, N. J.
Trout, H. G.....Buffalo.
United States Ship Building Co....New York.

PROJECTORS, ELECTRIC.
General Electric Co.....Schenectady, N. Y.
Westinghouse Electric & Mfg. Co.....
..... Pittsburg, Pa.

PUMPS FOR VARIOUS PURPOSES.
Blake, Geo. F., Mfg. Co.....New York.
Great Lakes Engineering Works Detroit.
Kingsford Foundry & Machine Works....
..... Oswego, N. Y.

PUNCHES, RIVETERS, SHEARS.
Allen, John F. .....New York.

RANGES.
Russell & Watson .....Buffalo

REFRIGERATING APPARATUS.
Great Lakes Engineering Works.....Detroit.
Roelker, H. B. .....New York.

REGISTER FOR CLASSIFICATION OF VESSELS.
Great Lakes Register .....Cleveland.
Record of American & Foreign Shipping..
.....New York.

REPAIRS—ENGINE AND BOILER.
(See also Boiler Manufacturers and Engine Builders.)
Georgian Bay Engineering Works.....
.....Midland, Ont.
Gogebic Steam Boiler Works....Duluth, Minn.
Forest City Boiler Co.....Cleveland.
Marine Iron Co.....Duluth, Minn.

RIVETING MACHINES.
Allen, John F.....New York.

RIVETS, STEEL, FOR SHIPS AND BOILERS.
Bourne-Fuller Co.....Cleveland.

SAFETY VALVES.
American Steam Gauge & Valve Mfg. Co.
..... Boston.
Ashton Valve Co.....Boston.
Crane Co. .....Chicago.
Lunkenheimer Co. .....Cincinnati.

SAIL MAKERS.
Baker, Howard H. & Co.....Buffalo.
Upson-Walton Co.....Cleveland.
Wilson & Silsby .....Boston.

SALVAGE COMPANIES.
See Wrecking Companies.

SEARCH LIGHTS.
General Electric Co.....Schenectady, N. Y.
Westinghouse Electric & Mfg. Co.....
.....Pittsburg, Pa.

SHEARS.
See Punches, Rivets, and Shears.

SHIP AND BOILER PLATES AND SHAPES.
Bourne-Fuller Co.....Cleveland.
Otis Steel Co.....Cleveland.

SHIP BUILDERS.
American Ship Building Co.....Cleveland.
Atlantic Works .....East Boston, Mass.
Bertram Engine Works Co., Ltd.Toronto, Can.
Buffalo Dry Dock Co.....Buffalo.
Cramp, Wm. & Sons.....Philadelphia.
Craig Ship Building Co.....Toledo, O.
Chicago Ship Building Co.....Chicago.
Detroit Ship Building Co.....Detroit.
Fore River Ship & Engine Co..Quincy, Mass.
Great Lakes Engineering Works.....Detroit.
Jenks Ship Building Co....Port Huron, Mich.
Lockwood Mfg. Co.....East Boston, Mass.
Manitowoc Dry Dock Co.....Manitowoc, Wis.
Milwaukee Dry Dock Co.....Milwaukee.
Newport News Ship Building Co.....
.....Newport News, Va.
Roach's Ship Yard .....Chester, Pa.
Shipowner's Dry Dock Co.....Chicago.
Smith & Son, Abram.....Algonac, Mich.
United States Ship Building Co..New York.
Willard, Chas. P. & Co.....Chicago.

SHIP CHANDLERS.
Baker, Howard H. & Co.....Buffalo.
Marine Mfg. & Supply Co.....New York.
Upson-Walton Co.....Cleveland.

SHIP LANTERNS AND LAMPS.
Russell & Watson .....Buffalo.

SHIP TIMBER.
Martin-Barriss Co.....Cleveland.

SMOOTH-ON COMPOUND, FOR REPAIRS.
Smooth-On Mfg. Co.....Jersey City, N. J.

STAYBOLTS, IRON OR STEEL, HOLLOW OR SOLID.
Falls Hollow Staybolt Co..Cuyahoga Falls, O.

STEAM VESSELS FOR SALE.
Elwell, Jas. W. & Co.....New York.
Gilchrist & Co., C. P. .....Cleveland.
Holmes, Samuel .....New York.
Lester, S. S. .....Quebec, Can.
McCarthy, T. R.....Montreal, Can.
Weeks, F. H.....New York.

STEAMSHIP LINES, PASS. AND FREIGHT.
American Line .....New York.
Anchor Line .....Buffalo.
Cleveland & Buffalo Transit Co..... Cleveland.
Erie & Western Trans. Co.....Buffalo.
Goodrich Trans. Co.....Chicago.
International Mercantile Marine Co.....
..... Philadelphia.
Manitou Steamship Co.....Chicago.
Mexican-American S. S. Co..New Orleans, La.
New York & Cuba Mail S. S. Co ..... New York.
Niagara, St. Catharines & Toronto Ry. &
Nav. Co. .....St. Catharines, Ont.
Northern Michigan Trans. Co.....Chicago.
Red Star Line .....New York.
Richelieu & Ontario Nav Co. .. Montreal, Can.
United Fruit Co .....Boston.

STEEL CASTINGS.
Macbeth Iron Co.....Cleveland.
Otis Steel Co.....Cleveland.
Seaboard Steel Casting Co.....Chester, Pa.

STEERING APPARATUS.
American Ship Building Co.....Cleveland.
Chase Machine Co.....Cleveland.
Dake Engine Co.....Grand Haven, Mich.
Detroit Ship Building Co.....Detroit.
Hyde Windlass Co.....Bath, Me.
Jenks Ship Building Co....Port Huron, Mich.
Marine Mfg. & Supply Co.....Cleveland.
Moulton Steering Engine Co.....New York.
Pawling & Harnischfeger .....Milwaukee.
Sheriffs Mfg. Co.....Milwaukee.

SUBMARINE DIVING APPARATUS.
Morse & Son, A. J.....Boston.
Schrader's Son, A.....New York.

SURVEYORS, MARINE.
Gaskin, Edward .....Buffalo.
Hynd, Alexander .....Cleveland.
Lovejoy, H. O.....Buffalo.
Matteson & Drake .....Philadelphia.
Parker Bros. Co., Ltd.....Detroit.
Nacey, James .....Cleveland.
Rice, Henry .....Buffalo.
Steel, Adam .....Cleveland.
Wood, W. J.....Chicago.

TESTS OF MATERIALS.
Hunt, Robert W. & Co.....Chicago.
Pittsburg Testing Laboratory, Ltd....Pittsburg.

TILING, INTERLOCKING RUBBER.
New York Belting & Packing Co...New York.

TOOLS, METAL WORKING, FOR SHIP AND ENGINE WORKS.
Allen, John F.....New York.
Watson-Stillman Co.....New York.

TOOLS, WOOD WORKING.
Atlantic Works, Inc.....Philadelphia.

TOWING MACHINES.
American Ship Windlass Co..Providence, R. I.
Chase Machine Co.....Cleveland.

TOWING COMPANIES.
Donnelly Salvage & Wrecking Co.....
.....Kingston, Ont.
Great Lakes Towing Co.....Cleveland.
Midland Towing & Wrecking Co., Ltd....
.....Midland, Ont.

TRAPS, STEAM.
Kieley & Mueller .....New York.
Lunkenheimer Co. .....Cincinnati.
Sturtevant Co., B. F., ...Hyde Park, Mass.

TRUCKS.
Boston & Lockport Block Co.....Boston.

TUBING, SEAMLESS.
Shelby Steel Tube Co.....Pittsburg, Pa.

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VALVES, STEAM SPECIALTIES, ETC.

American Steam Gauge & Valve Mfg. Co. ..... Boston.
Ashton Valve Co. ..... Boston.
Crane Co. ..... Chicago.
Jenkins Bros. ..... New York.
Kieley & Mueller ..... New York.
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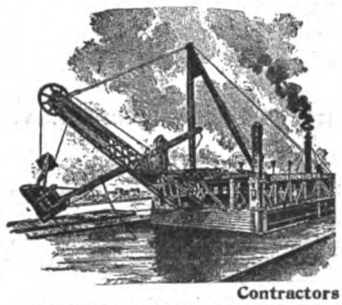

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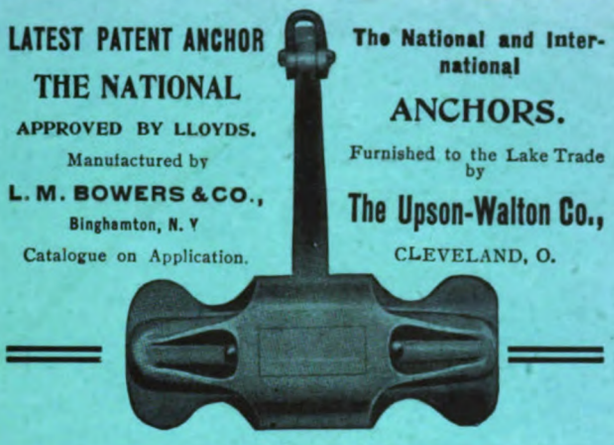

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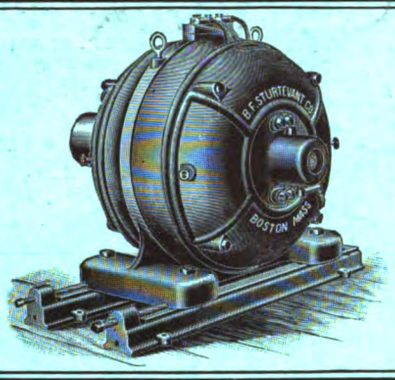

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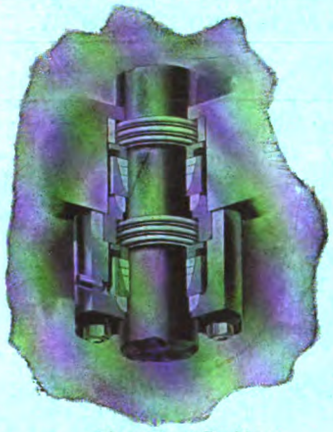

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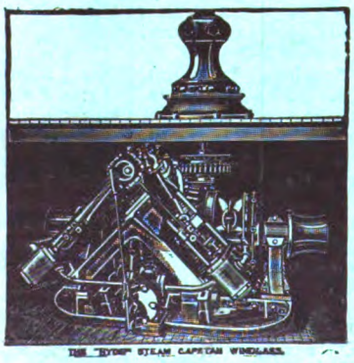

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